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GEOLOGY AND MINERAL RESOURCES OF THE CORONA SOUTH QUADRANGLE

CALIFORNIA DIVISION OF MINES

BULLETIN 178

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GEOLOGY OF THE CORONA SOUTH QUADRANGLE AND THE SANTA ANA NARROWS AREA

RIVERSIDE, ORANGE, AND SAN BERNARDINO COUNTIES, CALIFORNIA

AND

MINES AND MINERAL DEPOSITS OF THE CORONA SOUTH QUADRANGLE

RIVERSIDE AND ORANGE COUNTIES, CALIFORNIA

By CLIFFTON H. GRAY, JR.
Mining Geologist, California Division of Mines

BULLETIN 178

CALIFORNIA DIVISION OF MINES
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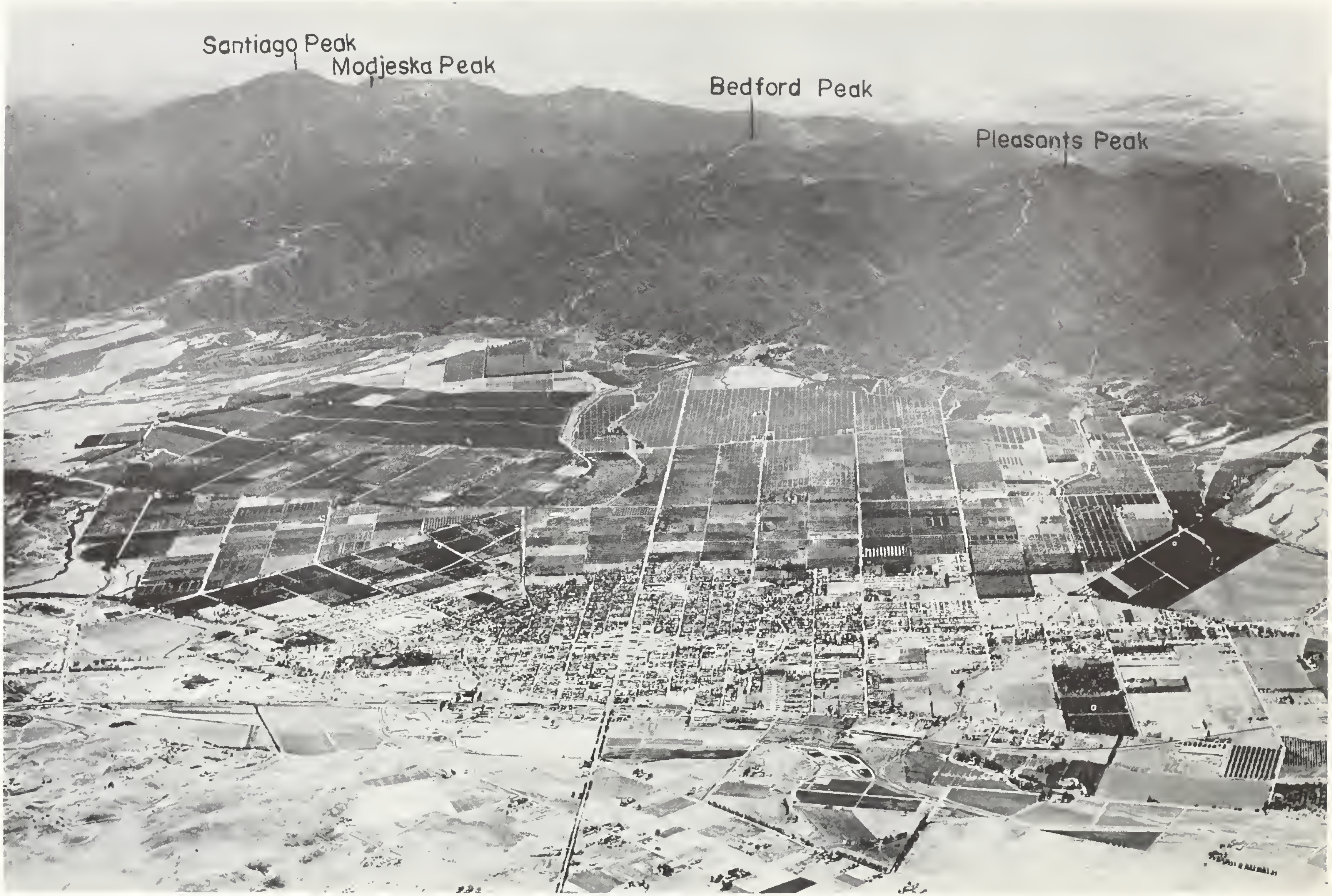

FIGURE 1. (Frontispiece). Oblique air photo of Corona and the Santa Ana Mountains taken April 29, 1957, camera facing south. The city of Corona (originally known as South Riverside in the 1880's and then characterized as the "Queen City," now as the "Circle City") in the foreground. The surrounding citrus groves are developed on a compound alluvial fan surface. Temescal Wash (northwest end of the Corona-Elsinore trough) is to the left. From right to left the trails leading up the ridges to the crest of the mountains are: Skyline Drive (extreme right, middle distance), Hagador fire break (Hagador Canyon to left), Main Street fire break (Main Street Canyon to left), Eagle Truck Trail (Eagle Canyon to right), Bedford Motorway (Bedford Canyon to right). The Main Divide Truck Trail is visible along the crest of the mountains. The low foothills consist of Cretaceous and Paleocene sedimentary rocks to the right of Hagador Canyon and Tertiary sediments to the left. The Elsinore fault bounds the mountain front and separates the Cretaceous and Tertiary sediments from the basement complex of volcanic and metasedimentary rocks which form the main mountain mass. The low San Joaquin Hills are in the background beyond the Santa Ana Mountains. *Photograph by Pictorial Crafts Incorporated, San Bernardino, California.*

ABSTRACT

The Corona South quadrangle and the adjoining Santa Ana narrows area lie in the northern part of the Peninsular Ranges. They contain the northwest end of the Elsinore trough which marks the trace of the Elsinore fault zone and trends northwestward across the center of the mapped area. The Chino fault diverges north-northwestward from its apparent junction with the Elsinore fault near the eastern margin of the Corona South quadrangle.

The oldest rocks, those of the Triassic Bedford Canyon formation, are metasedimentary in character, and occur mainly in the Santa Ana Mountains southwest of the Elsinore fault. Here they have been intruded by late Mesozoic plutonic rocks of the southern California batholith and in a few places are unconformably overlain by Jurassic (?) volcanic rocks. Northeast of the Elsinore fault is a succession of sedimentary rocks, several thousand feet thick, which includes rocks of Upper Cretaceous through Quaternary age. These units are of types found to the west in the Los Angeles Basin.

The dominant structural features are the Elsinore and Chino zones of high-angle reverse dip-separation faults and a synclinal trough which extends from the Puente-Chino Hills southeastward beyond Corona and lies nearly parallel to and to the northeast of the Elsinore fault. The surface distribution of Cretaceous sedimentary rocks indicates a probable minimum vertical displacement of 1,500 feet along the Elsinore fault southwest of Corona, whereas to the southeast a displacement of more than 5,000 feet is suggested by the difference in elevation of the basement complex on opposite sides of the fault. In post-Pliocene time, and perhaps throughout their history, the Elsinore and Chino fault zones have had an apparent high angle reverse sense of movement. Large lateral displacement may have occurred in pre-Pliocene time, but has not been demonstrated in the mapped area. In the Corona area the Elsinore trough is probably a faulted syncline.

Mining operations, especially for clay, crushed and broken stone, and glass sand, have been carried on since the late nineteenth century. Repeated, though unsuccessful, attempts have been made to find petroleum.

GEOLOGY OF THE CORONA SOUTH QUADRANGLE AND THE SANTA ANA NARROWS AREA

RIVERSIDE, ORANGE, AND SAN BERNARDINO COUNTIES, CALIFORNIA *

By CLIFFTON H. GRAY, JR.
Mining Geologist, California Division of Mines

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* Based in part upon a thesis presented to the Claremont Graduate School in partial fulfillment of the requirements for the degree of Master of Arts in Geology.

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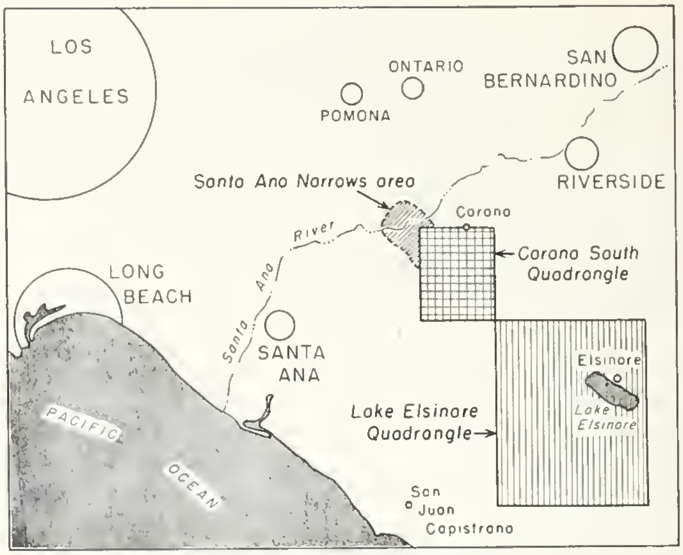

FIGURE 2. Outline map of a portion of southern California and index map of Corona South quadrangle-Santa Ana narrows area.

INTRODUCTION

Location and Accessibility. The area herein described and shown on the accompanying maps lies mostly in western Riverside County, California, but the northwestern part of the map also includes small bits of San Bernardino and Orange Counties and the southwestern part of the Corona South quadrangle lies in Orange County. The approximate geographical center of the area is 4 miles southwest of Corona and 45 airline miles southeast of Los Angeles. The Santa Ana Mountains, one of the Peninsular Ranges, bound the area on the southwest and form the highest and most rugged topography.

In the central part of the area, along the northeastern margin of the Santa Ana Mountains, the Corona compound fan surface slopes gently toward the northeast across the northwest end of the Corona-Elsinore trough, a graben-like valley that extends from Corona to Elsinore. The Corona fan extends as far as Temescal Wash, which marks the northeast side of the Corona-Elsinore trough, beyond which the topography again rises to form the Cajalco bench (Perris Block, Temescal Mountains, or Gavilan Hills).

The northwest part of the map area is occupied by the southeastern tip of the Puente Hills (Chino Hills). These low hills are separated from the Santa Ana Mountains by the west-southwestward flowing Santa Ana River. The whole area makes a strip approximately fifteen miles long and contains about 75 square miles. Most of the district is reasonably accessible by wheeled vehicles. State Highways 18 and 71 cut across the region and dirt roads give access to the lower parts of the major canyons. Several U. S. Forest Service fire control roads cross the Santa Ana Mountains, but only the Corona Skyline Drive is suitable for standard automobiles. The region southwest of the Elsinore fault is within the Cleveland National Forest which is closed to public use during the summer months because of the high fire hazard.

Physical Features. The area to be discussed lies in the Peninsular Ranges province of southern California. The region in general consists of alluviated valleys separated by rather narrow mountain ranges, which trend northwestward. The flat lands are mostly less than 1,500 feet above sea level and slope gently up to the bases of the mountain ranges. The mountains rise sharply above the alluvial plains to summits that are commonly between 3,000 and 5,000 feet above sea level. Extending northeastward from the Santa Ana Mountains toward Corona is a compound alluvial fan that ranges from 700 feet at Corona to about 1,400 feet elevation at Bedford Canyon.

The drainage system of the Corona area shows a crude gridiron pattern, and surface water flows intermittently. Most of the area is drained by Temescal Creek which flows northwestward through Temescal Canyon. Northwest of the city of Corona it empties into the southwestward-flowing Santa Ana River, the major river, and the only perennial river, in the region. The northeast side of the Santa Ana Mountains, east of Main Street Canyon, drains northeastward to Temescal Creek. West of Main Street Canyon the Santa Ana Mountains drainage is to the north and northwest into or toward the Santa Ana River, but many of the smaller streams flow only a short distance from the mountains before losing their identity on the old alluvial surface of the Corona fan. In general, the main canyons on the east slope of the Santa Ana Mountains are normal to the trend of the mountains, but their tributaries, which enter the larger canyons at right angles, are parallel with the axis of the mountain mass. The principal canyons on the west slope of the Santa Ana Mountains, in the southern part of the area, are nearly parallel to the mountains, and their tributaries are transverse. Their streams eventually join Santa Ana River to the west through Santiago Creek.

The summers are long and warm, the winters are generally moderate, and the air is dry. In summer, showers are infrequent and of short duration. In winter, the precipitation is mainly rain. Snow occasionally falls on the higher peaks and very rarely at lower elevations. The average mean annual temperature is reported to be 62.7° F at Corona, and the annual rainfall there averages 13.3 inches.

The vegetation is sparse in the lower country but is commonly dense and difficult or impossible to traverse above the 1,000-foot contour. It is the sagebrush type characteristic of the California chaparral life zone. Higher in the mountains there is an abundance of thick brush and a few live oak and pine trees. The common plants include black sage, sagebrush, California holly, elderberry, mountain mahogany and prickly pear cactus.

Previous Geologic Work. No previous geologic work has covered in detail the entire area of this report. Several published reports, however, include the general region or parts thereof, but most papers have been of a reconnaissance nature or deal with small areas.

J. D. Whitney, in 1865, gave the first description of the Santa "Anna" and Temescal Ranges in volume I of the Geological Survey of California. He noted the topography, occurrence of sedimentary and crystalline rocks and the complex structure. P. H. Dudley (1935) and R. J. Sampson (1935) described the geology and mineral resources of a portion of the Perris Block, which includes that part of the area northeast of Temescal Canyon. Later Dudley (1936) described the physiographic history of the Perris Block. J. C. Sutherland (1935) described the clays of Riverside and Orange Counties, including those of the old McKnight mine southwest of Corona. In 1945 the California Division of Mines published a brief account of the mining activities of the Riverside County part of the area in the State Mineralogist's Report.

Esper S. Larson, Jr. (1948) described the crystalline rocks in the region southeast of the Santa Ana River. The sedimentary rocks were not differentiated. Later E. H. Pampeyan (1952) mapped in more detail the crystalline rocks of the Cajalco area to the east of, and including, the Temescal Canyon part of the Corona South quadrangle. J. E. Schoellhamer and others (1954) published a detailed geologic map of the northern Santa Ana Mountains, including the Black Star Canyon quadrangle adjacent to the west edge of the Corona South quadrangle. Also in 1954, R. H. Jahns published a generalized geologic map of the Peninsular Ranges province and a geologic guidebook on the northern part of the Peninsular Ranges province.

Purpose and Methods. This paper describes the geology of the northeastern Santa Ana Mountains, the southeastern Puente-Chino Hills, and the northern part of the Elsinore-Corona trough with special emphasis on structure, particularly the relationships of the Elsinore, Whittier, and Chino faults.

Most of the field mapping in the Santa Ana Mountains was done on 1 : 12,000 Department of Agriculture aerial photos, series AXM. The Temescal Canyon region was mapped on Fairchild aerial photos at the scale of 1 : 12,000. Northwest of the Santa Ana River the field mapping was done on 1 : 12,000 U. S. Geological Survey aerial photos, series GS-CP.

The principal base map on which the field data were plotted is the 7½ minute U. S. Geological Survey Corona South quadrangle sheet published in 1954. A planimetric base map was used for the Santa Ana narrows area, and was traced from the 7½ minute Prado Dam and Black Star Canyon quadrangle sheets of the U. S. Geological Survey, published in 1950.

Geologic mapping of the Corona South quadrangle and Santa Ana narrows area was started in September 1950 and continued intermittently until February 1957. Most of the detailed mapping of the sedimentary rocks was done between January and August of 1951. The contacts between the igneous and metasedimentary rocks are generally shown as approximate as, in most places, they are obscured by dense brush.

The crystalline rocks north of State Highway 71 in the Temescal Canyon region were examined only in reconnaissance. The distribution of these units was taken, with minor modifications, from an unpublished report by E. H. Pampeyan (1952).

Acknowledgments. The writer wishes to express his appreciation of aid and information furnished by A. O. Woodford and J. S. Shelton of the Pomona-Claremont

College Geology Department and J. E. Schoellhamer and R. F. Yerkes of the U. S. Geological Survey. J. G. Vedder of the U. S. Geological Survey checked the Paleocene, Miocene and Pliocene megafossils. Patsy B. Smith of the U. S. Geological Survey kindly identified the Pliocene and Miocene microfaunas. Richard H. Jahns of the California Institute of Technology read the structural geology chapter and contributed helpful suggestions.

The willing cooperation of the many property owners in allowing the writer to go upon their properties is gratefully acknowledged. The U. S. Forest Service was most cooperative in allowing the writer access to the Cleveland National Forest.

Field expenses were partly defrayed by the State Division of Mines and the Woodford Fund, Pomona College.

The writer owes much to his associates of the Division of Mines and in particular to Oliver E. Bowen, Jr. and Lauren A. Wright, who read the manuscript critically. R. A. Crippen, Jr. assisted materially in preparation of the illustrations.

DESCRIPTIVE GEOLOGY

General Features

The Corona area may well represent the easternmost extension of sedimentary rock types found in the Los Angeles Basin, which is adjacent to the area to the west. The area appears to have been once covered by a rather thick and nearly complete succession of Mesozoic and Tertiary sedimentary rocks (pl. 4). In Plio-Pleistocene time these rocks were folded into a great anticline with the axial trace roughly along the present crest of the Santa Ana Mountains. A syncline was formed to the northeast and is now exposed in the Puente-Chino Hills where it is known as the Arena Blanca syncline. This syncline may extend to the southeast into the northwest end of the Corona-Elsinore trough at least as far as Brown Canyon, which is 7 miles southeast of Corona, at the east edge of the Corona South quadrangle. Later, probably in late Pleistocene and Recent time, the core of the Santa Ana Mountains, which consists of pre-Tertiary crystalline rocks, was raised by a high-angle reverse fault along the northeastern margin of the mountains.

The oldest rock unit exposed is the Bedford Canyon formation of metasedimentary rocks. It is Triassic in age and forms the highest, central portion of the Santa Ana Mountains in the area, and part of the Perris Block, which lies mostly outside the mapped area east of Temescal Wash.

Resting unconformably upon, but locally faulted against, the Bedford Canyon metasedimentary rocks in the Santa Ana Mountains are the Jurassic (?) Santiago Peak volcanics. Intrusive rocks, probably related to the Santiago Peak sequence, cut the Bedford Canyon strata.

East of the Corona-Elsinore trough, in the Temescal Canyon area, are crystalline rocks that have been described (Pampeyan, 1952, p. 14) as representing two closely-spaced and possibly related periods of intrusion. In the first period the Temescal Wash quartz latite porphyry and the Corona hornblende granodiorite porphyry were successively intruded into older marine sedimentary rocks. The second period is represented by the emplacement of batholithic rocks—Cajalco quartz monzonite and the Home Gardens quartz monzonite porphyry—into the sedimentary units and earlier igneous bodies. Pampeyan suggests that the first period of intrusion may be Jurassic and Early Cretaceous in age and that the second period is later Cretaceous. If this is true, the Santiago Peak volcanics and the intrusive bodies related to them in the Santa Ana Mountains are probably related in time to the first period of intrusion in the Temescal Canyon region.

The plutonic rocks of the second period are represented in the mapped area of the Santa Ana Mountains by the San Marcos gabbro and in the Temescal Canyon area by the Cajalco quartz monzonite and the Home Gardens quartz monzonite porphyry. These rock types are also present southeast of the Corona area in the Santa Ana Mountains (Larsen, 1948, map). They also occur beneath the younger rocks of the Corona-Elsinore trough, as samples from three wells east of Bedford Canyon reveal biotite quartz diorite, biotite quartz monzonite, and hornblende granodiorite.

In the Santa Ana Mountains the oldest unmetamorphosed sedimentary rock unit exposed is conglomerate of the Cretaceous Trabuco formation. It is in fault contact with the Santiago Peak volcanic rocks and apparently grades both vertically and laterally into the basal sandstone and conglomerate of the Late Cretaceous Ladd formation. The basal part of the Ladd formation is the Baker Canyon conglomerate member of sandstone and conglomerate. It is conformably and successively overlain by the Holz shale member, and undifferentiated siltstone and shale with interbedded sandstone and conglomerate also of the Ladd formation.

A fault contact separates the Ladd formation from the younger Paleocene Silverado formation, composed of marine and nonmarine beds that are chiefly sandstone, conglomerate and clayey siltstone which intertongue. The Silverado formation in the Santa Ana narrows area grades imperceptibly upward into Eocene Santiago formation siltstone, sandstone, and conglomerate.

Resting unconformably upon the Silverado formation in the eastern part of the Corona South quadrangle are sandstone, conglomerate, and siltstone of the late Eocene to early Miocene Vaqueros-Sespe group, which is mapped as a single unit. In the southeastern Puente-Chino Hills this unit is conformably overlain by sandstone of the middle Miocene Topanga formation.

In El Cerrito Village area of the Corona South quadrangle the Topanga formation apparently rests unconformably on Silverado sandstone and is succeeded conformably by sandstone, conglomerate and shale of the upper Miocene Puente formation, undifferentiated. West of the map area, in the northwestern tip of the Santa Ana Mountains and in the Puente-Chino Hills, Schoellhamer and others (1954, map) have divided the Puente formation into four members. From bottom to top these are: La Vida member, the Soquel member, the Yorba member, and the Sycamore Canyon member.

On Scully Hill in the Santa Ana narrows map area in the southeastern Puente-Chino Hills, the Topanga formation is conformably overlain by La Vida member (shale) which is in fault contact with the overlying Soquel member (sandstone) of the Puente formation.

The Yorba member (shale) conformably overlies the Soquel member and is conformably overlain by the Sycamore Canyon member (sandstone and conglomerate) of the same formation. The Puente strata grade upward into Pliocene (?) sandstone, conglomerate, and shale.

Along the northeastern margin of the Santa Ana Mountain the Vaqueros-Sespe group is overlain in fault contact by the Puente formation, mapped as undifferentiated, which in turn is apparently conformably overlain by Pliocene (?) rocks, which consist of sandstone and minor conglomerate and shale beds.

The central part of the area (in the vicinity of Corona) is a dissected compound alluvial fan. Well-developed terrace deposits rest unconformably on the Mesozoic and Tertiary sedimentary sequence at many places. Alluvial "dirty" appearing sand and gravel fill the stream valleys.

Stratigraphy

Triassic System

Bedford Canyon Formation

The oldest rocks in the mapped area are moderately metamorphosed argillite, slate, graywacke, and quartzite with minor amounts of limestone and local thin-bedded tuffaceous strata. These comprise the Bedford Canyon formation and underlie much of the northern part of the Santa Ana Mountains. Somewhat similar metasedimentary rocks have been mapped (Larsen, 1948, map) for distances of at least 50 miles to the southeast and 30 miles east of the Corona South quadrangle.

Smith (1898, pp. 776-786) applied the term Santa Ana to a limestone in slates in the western part of the Santa Ana Mountains. Merrill (1916, pp. 639-640) used the term Santa Ana metamorphic strata for the slates. Dudley (1935, p. 493) called a series of well-exposed metasedimentary rocks near Elsinore, California, the Elsinore metamorphic series. Larsen (1948, p. 19) proposed the name Bedford Canyon formation for the metamorphic rocks of the region because "the rocks are well exposed and contain fossils in that canyon". This later name seems preferable and is used herein.

The rocks of the Bedford Canyon formation crop out continuously from the eastern margin of the area to Tin Mine Canyon and form the crest of the Santa Ana Mountains. The formation also is well-exposed along the north side of Temescal Canyon where the canyon is entered by Cajalco Road. Because of the complex nature of these metamorphic rocks, their poor exposures, the lack of traceable beds or marker horizons, and the generally impenetrable brush-covered slopes, the formation was not subdivided on the geologic map. The Bedford Canyon formation commonly forms weak, rounded slopes, a much less rugged topography than that developed on the overlying Santiago Peak volcanics. The Bedford Canyon strata are characterized by alternating thin beds, ranging from one inch to several feet in thickness, of impure feldspathic sandstone and somewhat slaty shale.

Probably the most abundant metasedimentary rock types in the Bedford Canyon formation in the Santa Ana Mountains are silty argillite and slate. On fresh surfaces these rocks are black or blue-black with a very fine-grained texture. Slaty cleavage is only weakly developed.

Impure quartzite and graywacke are comparable with argillite in abundance, and are well-exposed in the railroad cut just north of Cajalco Road, along Tin Mine Canyon, and along several fire control roads in the Santa Ana Mountains. The quartzite and graywacke have in general a bluish-gray to yellow-brown or rusty orange color and form steep-sided gorges in the Santa Ana Mountains. Lenses of grayish-black conglomerate, containing angular pebbles and cobbles, are locally present. Bedding is indistinct, whereas fractures and joints are well-developed.

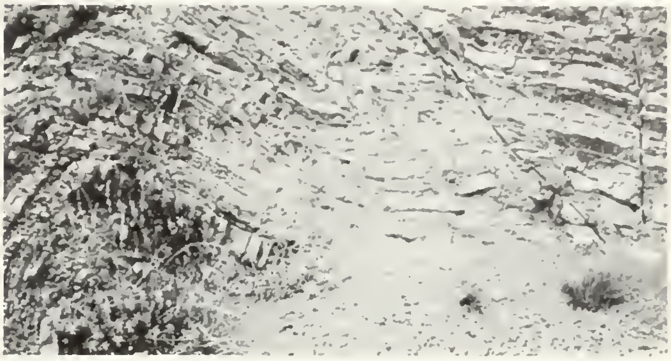

FIGURE 3. Sheared, strongly deformed, and moderately metamorphosed interbedded graywacke (light-colored beds) and slaty shale and argillite (dark-colored beds) of the Bedford Canyon formation. Note minor faults. Typical roadcut exposure along Silverado Motorway, half a mile north of Silverado Canyon. Observer faces east.

The quartzite exposures consist almost wholly of fine- to medium-grained, subrounded to subangular quartz grains, but also contain a minor amount of feldspar and sparse heavy minerals. Microscopic examination shows that some of the quartzite grains consist of quartz in a very fine-grained silicified matrix, rather than interlocking quartz grains. Quartz veinlets are replaced by iron oxides and grains of iron oxides are abundant. Some of the quartzite is poorly sorted with much intersticial clay.

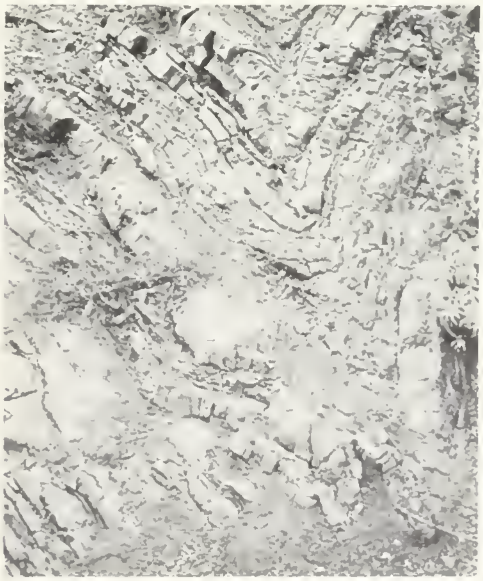

FIGURE 4. Closely folded, thin-bedded, graywacke and argillite of the Bedford Canyon formation. Exposed in cut on Silverado Motorway. Observer faces east.

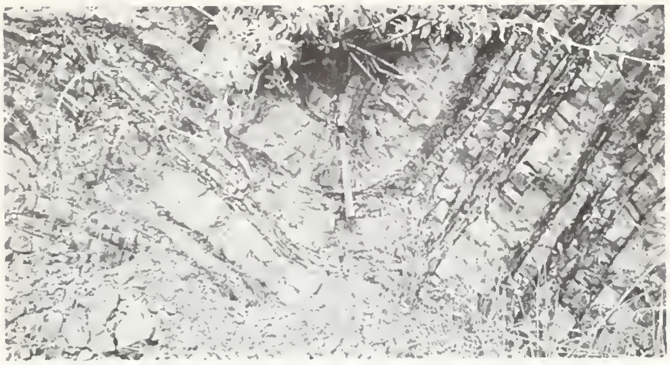

Figure 5. Minor fold in the Bedford Canyon formation showing detail of interbedded graywacke and slaty argillite. Exposed in cut on Silverado Motorway. Observer faces east. Figs. 3, 4, and 5 are typical exposures of the principal lithology of the Bedford Canyon formation and illustrate the similar appearance of most outcrops in large areas underlain by these rocks.

The typical graywacke is poorly sorted and contains subangular, tightly packed to interlocking quartz, feldspar, and dark rock fragments that range in diameter from 0.1 mm to 1.5 mm. Minor intersticial silicified clay is present and much secondary iron oxide occurs on quartz and feldspar grain contacts. Some specimens contain many small grains of epidote and have siliceous cement. Calcite, however, is the principal cement and forms as much as 15 percent of the graywacke. Good exposures in road cuts show that the argillite, slate and graywacke are considerably deformed (figs. 3, 4, 5). The rocks are generally much fractured and jointed and weathered a yellow-brown or tan. Many exposures show thin, alternating beds of argillite and fine-grained, impure quartzite or graywacke.

Dark gray to blue-gray and black limestone with an aphanitic texture crops out in only a few places in the Corona South quadrangle. It occurs as small, irregular lenses within the slate and graywacke. The limestone is crystalline, is poorly bedded, massive, and weathers light gray or brownish-gray. In a few exposures the limestone is somewhat banded, perhaps as a result of flowage, but the banding may represent original bedding. The carbonate bodies appear to be parallel in attitude with the enclosing arenaceous metasedimentary rocks and stand out as resistant ledges. The limestone is fetid, cut by numerous veinlets of medium-grained, macrocrystalline, secondary white calcite and is moderately silicified. In some places, especially on weathered surfaces, the limestone appears to be a breccia.

The largest lens of limestone (see fig. 23, in mineral deposits section) crops out along the west side of the East Fork of Ladd Canyon. This carbonate lens is about 100 to 200 feet in width and several hundred feet in strike (?) length. This limestone body may have formed in quiet shallow water, mostly as an algal reef. The lower few feet of limestone contains many pelecypods with the valves attached and a few small ammonites and upward the limestone contains abundant algallike forms. The upper part, however, appears to be more elastic than the lower fossil-bearing strata. Several smaller limestone lenses occur along the east side of Bedford Canyon, east of Bedford Motorway. Limestone beds, only a few feet wide and several tens of feet, or less, long were observed at several places along the crest of the mountains and on the west slope.

White to greenish-gray strata, probably tuffaceous, crop out along the Main Divide truck trail at the west edge of the Corona South quadrangle and on the ridge between Ladd Canyon and its west fork. These rocks are thin-bedded, much fractured, very fine-grained and highly siliceous. The tuffaceous bodies, which have areal extents of only a few hundred feet, are apparently intercalated with graywacke, slate and argillite near the top of the Bedford Canyon formation.

In most places the Bedford Canyon formation is overlain, apparently unconformably, by the Santiago Peak volcanics. Locally, however, it is faulted against the volcanics. East of Bedford Canyon, along the northeastern side of the mountains, the Bedford Canyon formation is faulted against Tertiary sedimentary rocks.

According to Irving (1935) a thickness of 11,800 ± feet of metasedimentary rocks occurs a few miles southeast of the Corona South quadrangle in the Perris Block along Temescal Canyon. The true thickness of the Bedford Canyon formation in the mapped area is not known as the base was not encountered and the top has been removed by erosion. Larsen (1948, p. 22) reports that the base of the Bedford Canyon formation is nowhere exposed but that probably a thickness of 20,000 feet is exposed in the Santa Ana Mountains. As the metasedimentary rocks of the formation show such a great variation of attitude, are so highly deformed, so poorly exposed, and rarely show well-preserved bedding an attempt to measure sections or thickness would prove fruitless. However, the writer suspects that the 20,000-foot thickness figure is probably excessive for the Bedford Canyon formation in the northwestern part of the Santa Ana Mountains.

Paleontology

Fossils of Triassic age from limestone in upper Bedford Canyon, 6 miles southeast of Corona, and in the East Fork (?) of Ladd Canyon on the south slope of the mountains, have been reported by J. P. Smith (1898, p. 779), Mendenhall (quoted in Willis, 1912, p. 505), Cooper (quoted by Larsen, 1948, p. 18) and Engel (1959, pp. 19, 20, 22-24).

East of Bedford Canyon (from NW cor. sec. 29, T. 4 S., R. 6 W., S.B.M., 2600′ S and 400′ E) a tiny body of dark gray limestone crops out and is about 10 feet in diameter. This limestone (apparently the above mentioned Bedford Canyon locality) contains abundant rhynchonelloid brachiopod debris but the material collected by the writer (March 1956) was too poor to assign names. Engel (1959, p. 24) tentatively identified *Halorella* from this locality.

Fossils from a limestone body in the East Fork of Ladd Canyon have recently been illustrated by Engel (1959, pp. 20, 23) who assigns them to the pelecypod *Daonella sanctaeanae* Smith and to the Upper Triassic ammonite genera *Discotropites* and *Juvavites*.[1]

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[1] In April 1960, after this manuscript was prepared for publication, the writer, together with N. J. Silberling and J. E. Schoellhamer of the U. S. Geological Survey, collected several small, imperfectly preserved, ammonites and a number of specimens of one pelecypod, many with the valves attached, from the large limestone lens along the west side of the East Fork of Ladd Canyon (from SE cor. sec. 34, T. 4 S., R. 7 W., S.B.M., 900′ N. and 1,000′ W.). This is probably the same locality from which the fossils illustrated by Engel were obtained.

Jurassic (?) System

Intrusive Rocks Related to Santiago Peak Volcanics

Larsen (1948, p. 27) has noted that a number of small bodies of fine-grained granodiorite and related rocks, believed to be about the same age as the Santiago Peak volcanics, crop out in the Corona, Elsinore, and San Luis Rey 30-minute quadrangles. A similar age apparently can be applied to fine- to medium-grained, generally porphyritic basic intrusive rocks that form a group of small, irregular-shaped bodies in the Santa Ana Mountains in the southern part of the Corona South quadrangle. These bodies are mainly along the watershed divide between Bedford Peak and Bald Peak and along the Bedford Motorway; in a stock-like body in Silverado Canyon; and in a number of narrow dikes or sills, chiefly in the southeastern part of the quadrangle. The area underlain by these rocks totals about 2 square miles.

The granodiorite and related rocks are intrusive into Triassic Bedford Canyon formation metasedimentary rocks which are somewhat altered around some of the intrusive bodies. In a few places parts of intrusive bodies are faulted against the Bedford Canyon formation. The intrusive rocks are commonly resistant to weathering and form prominent high peaks and steep slopes along the crest of the Santa Ana Mountains, but there are also deeply weathered bodies. The intrusive rocks are gray or grayish-green in color, form rugged, angular outcrops, and in many places readily break into small fragments. In these respects, and also in their general petrologic features, these rocks resemble the mildly metamorphosed Santiago Peak andesitic volcanic rocks. The intrusive bodies are mostly hornblende andesite, with some quartz latite, hornblende diorite, and minor basaltic rocks. In many places the rock contains inclusions of sand grains and fragments of fine-grained sedimentary rocks, in a very fine-grained, severely altered, igneous groundmass. These masses apparently are shallow intrusions and marginal facies of larger and deeper intrusions. Small surface flows may be included in some intrusive bodies.

Larsen (1948, p. 27) believed these intrusive rocks to be associated with the Santiago Peak volcanic rocks because: (1) they are closely associated in space with the volcanic rocks; (2) have undergone about the same degree of metamorphism as the volcanic rocks; (3) are finer-grained and more porphyritic than the rocks of the batholith and have the texture characteristic of small volcanic plugs; and (4) wherever their relation to the batholithic rocks was determined, they are older. These criteria also apply to the intrusive bodies exposed in the Corona South quadrangle, except that at no place within the quadrangle was the relation between the intrusive rocks and those of the batholith observed.

The prominent, roughly circular intrusive body in Silverado Canyon is a dark green, cliff-forming, blocky weathering, hornblende andesite. A narrow, apparently closely associated zone of white, altered rhyolite tuff along its west margin is included with this body on the geologic map. The andesite contains feldspar crystals and hornblende, much replaced by chlorite, in a very fine-grained andesitic groundmass. Several smaller tabular intrusive bodies to the east along Silverado Canyon are of similar composition.

A large irregular stock near Bald Peak is mostly hornblende andesite, but is much contaminated by Bedford Canyon metasedimentary rocks and some basaltic material. This andesite contains large zoned and twinned andesine phenocrysts which are variously oriented in an altered groundmass. Ferromagnesian minerals generally are thoroughly altered, but some specimens contain hornblende and augite. The rock contains abundant chlorite, epidote, and secondary silica. Most samples show quartz veinlets and abundant secondary (?) iron oxides and iron sulfides (pyrite, pyrrhotite ?).

The irregularly shaped body along Bedford Motorway is also hornblende andesite. In some places it is a much altered, calcitized, chloritized andesitic (?) rock without ferromagnesian minerals. Elsewhere, andesine laths comprise the groundmass in which are abundant hornblende phenocrysts commonly altered to penninite. The rock has been epidotized and silicified and considerable opaque minerals (magnetite and pyrite ?) are present.

Southeast of Bedford Peak a small stock on the crest of the ridge forms a prominent topographic feature. It is a quartz latite porphyry and contains biotite and hornblende.

The dikes in the Bedford Canyon formation metasedimentary rocks are mostly andesite porphyries. Specimens from a dike in Brown Canyon show large andesine phenocrysts in a groundmass of feldspar, chlorite, and iron oxide grains. Ferromagnesian minerals are thoroughly altered but the rock contains pyrite cubes. Some dikes are quartz latite porphyries and contain phenocrysts of hornblende, feldspar, and augite in a groundmass of quartz, feldspar, and augite.

The stock at the crest of the mountains at the head of the West Fork of Ladd Canyon, just west of Pleasants Peak, is hornblende diorite. In some places it is a very coarse-grained hornblende diorite with the feldspar much altered. Elsewhere it exhibits diabasic, often a coarse, pronounced, ophitic texture with large phenocrysts of andesine and chloritized hornblende, and contains a considerable number of iron oxide grains. Some of the rock contains several percent of interstitial quartz. The entire stock contains much secondary carbonate, chlorite, and epidote. Along the west margin of this stock on a small knob at the crest of the mountains is a small body of green to blackish-green serpentine only about 150 feet in diameter. It is broken into small fragments, is slickensided, is cut by numerous calcite veinlets, and contains some soft, green, talcose material. In thin section the rock exhibits iron oxide (magnetite ?) grains and calcite "eyes". Rugged, cliff-forming dark reddish brown silica-carbonate rock with veinlets of iron oxide forms a crude aureole on the south and west sides of the serpentine body. The silica carbonate body occurs along a fault zone and is probably hydrothermal in origin and may be de-

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According to Ralph W. Imlay and Norman J. Silberling, Paleontology and Stratigraphy Branch, U. S. Geological Survey (personal communication, 1960), "the pelecypods in this collection belong to *'Daonella' sanctaeanae* Smith, a *Posidonia*-like form that probably represents a new genus. The ammonites are provisionally identified as follows:

Calliphylloceras sp. juv.
Partschiceras ? cf. P. grantzi Imlay
Lytoceras ? sp.
Hecticoceras ? (Sublunuloceras ?) sp.
Macrocephalites ? sp.

This fauna is Jurassic in age and is probably of early Late Jurassic (Callovian ?) age."

Inasmuch as these fossils occur in only one limestone lens, which has not been assigned a definite stratigraphic position in the Bedford Canyon formation, the age of the entire formation is not established. Perhaps the Bedford Canyon formation includes rocks of both Late Jurassic and Triassic age.

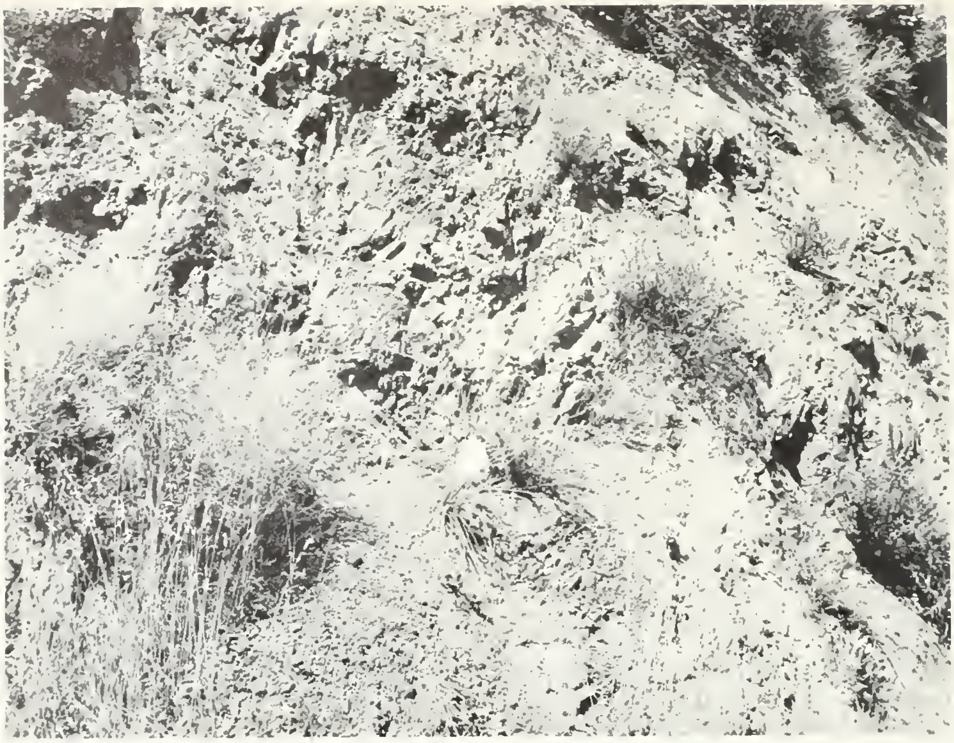

FIGURE 6. A typical exposure of the Santiago Peak volcanics (hornblende andesite). Cut at the foot of Skyline Drive, north side of Tin Mine Canyon. Observer faces west.

rived from alteration of serpentine. The serpentine is probably the alteration product of a ferromagnesian-rich phase of the hornblende diorite intrusive.

Santiago Peak Volcanics

According to Larsen (1948, p. 23) outcrops of the Santiago Peak volcanics lie in a discontinuous belt that extends from south of La Jolla nearly to the Santa Ana River. The exposed length of the belt is about 80 miles but its maximum width is not much over 10 miles. These rocks are exposed on both the northeast and southwest flanks of the Santa Ana Mountains. They were originally called the Black Mountain volcanics in La Jolla quadrangle by Hanna (1926, pp. 199-204).

On the east slope of the Santa Ana Mountains these volcanic rocks, which consist mostly of slightly metamorphosed andesitic flows and breccias, crop out from just west of Bedford Canyon to State Highway 18 at Santa Ana Canyon. South of Tin Mine Canyon and southeast to Bedford Canyon they form the middle elevations of the mountains, whereas to the northwest they extend to the crest. On the west slope the volcanic rocks crop out at the crest of the mountains in the vicinity of Pleasants Peak and extend southward along the West Fork of Ladd Canyon and west beyond the west margin of the Corona South quadrangle. These volcanic rocks are resistant to erosion and form rugged topography, commonly with sheer cliff faces.

In normal sequence the Santiago Peak volcanics apparently overlie the Bedford Canyon formation unconformably with almost 90° difference in dip, but locally the metasedimentary rocks are faulted against the volcanics and may be thrust over them. A small pod of Bedford Canyon quartzite, exposed along the Skyline Drive at the west edge of the Corona South quadrangle, has been engulfed by Santiago Peak andesite, and dikelets of the andesite invade the quartzite.

In general the volcanic rocks are dense and compact and on fresh exposures are dark grayish-green to greenish-black with some lighter colored zones. In many places they show a characteristic hypabyssal texture. The weathered surface of most outcrops is gray or greenish-

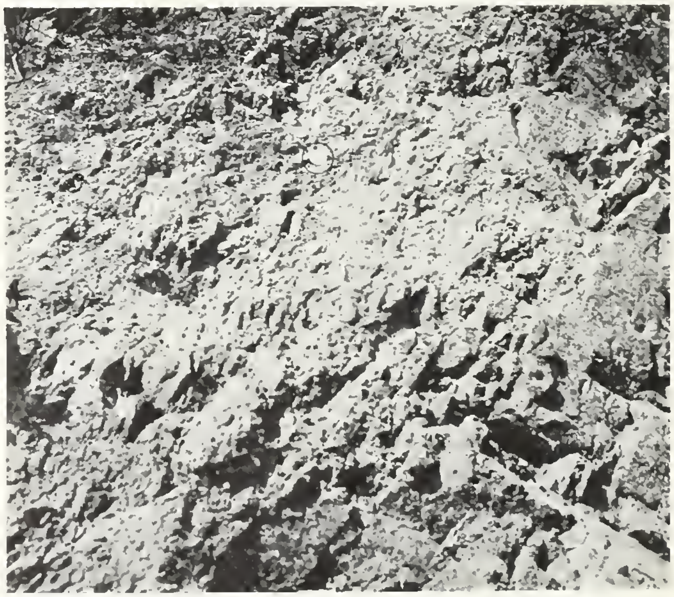

FIGURE 7. Detail of the Santiago Peak volcanics shown in fig. 6. Quarter (in circle) gives scale. The white plagioclase phenocrysts contrast with the dark greenish-gray groundmass.

gray and the overlying soil is dark reddish-brown, buff, or greenish-gray. Andesite and dacite are the commonest rock types; quartz latite and rhyolite are much less common. Most of the volcanic sequence is massive pyroxene or hornblende andesite. Phenocrysts of feldspar are commonly apparent in hand specimens; phenocrysts of mafic minerals are rarer. The groundmass is commonly aphanitic and is so altered to green secondary minerals that the rock might be called a "greenstone".

Evidently a flow breccia, commonly several hundred feet thick, forms a rather widespread basal unit in the volcanic rocks as it was found at several places near the contact with the underlying metasedimentary rocks. This flow breccia consists of angular pebble and cobble clasts of andesitic rock, graywacke, and slate in a fine-grained volcanic matrix. It is well-exposed in Ladd Canyon where it is as much as several hundred feet thick and is also well exposed in a belt 300 to 400 feet wide along the Main Divide truck trail at the west edge of the Corona South quadrangle. Other volcanic breccias and probably some tuffs are also present.

In Tin Mine Canyon is a green volcanic rock with phenocrysts of quartz and feldspar in a fine-grained groundmass. This rock appears to be more resistant to erosion than the andesite and ranges in composition from quartz latite porphyry to rhyolite. Dark minerals are present but altered. Secondary chlorite and epidote may be present.

A small exposure of a fine-grained purple acidic volcanic rock was observed along the Eagle Canyon truck trail. This rock is near the top of the Bedford Canyon formation and appears to have intruded the metasedimentary rocks. It displays flow banding and contains cryptocrystalline red glassy grains and a material which may be bleached green mica. It is probably an intrusive rock related to the Santiago Peak volcanics. Dacitic rocks are also present within the principal mass of andesitic rocks.

The thickness of the volcanic rocks cannot be measured but it probably is very great, and formerly this body of volcanic rock may have been much larger. Within the Corona South quadrangle the Santiago Peak volcanics crop out at elevations ranging from 1,600 to 3,900 feet. Thus a maximum present thickness of about 2,300 feet is suggested as the volcanic rocks at most places appear to be dipping gently. However, in a few places the volcanics appear to be steeply dipping so that the thickness may be much less than that suggested by the outcrop pattern.

Whether any bodies of the volcanic rock are infolded within the metasedimentary rocks is not known, but where relations are clear the volcanics do not appear to be infolded. Probably the lava flows spread over a surface of considerable relief on the old sedimentary sequence so that the volcanics may occupy their present position, in relation to the Bedford Canyon formation, in part as a result of the topography on the old surface, rather than as a result of infolding.

Larsen (1948, p. 24) believes the volcanics to be Jurassic in age as they overlie the Triassic rocks unconformably, have undergone about the same degree of metamorphism, and are intruded by all the batholithic rocks. The writer agrees that the volcanics are clearly post-Bedford Canyon in age and, inasmuch as clasts of the volcanics are found in early Upper or late Lower Cretaceous sedimentary rocks, they are tentatively assigned to the Jurassic period. However, the volcanic rocks might be, at least in part, of Early Cretaceous or mid-Cretaceous age.

Temescal Wash Quartz Latite Porphyry

Dudley (1935, p. 497) named a blue-black to gray porphyritic rock found on the east side of Temescal Wash the Temescal dacite porphyry. Larsen (1948, p. 36) has shown that the composition is more nearly that of quartz latite, and proposed the name Temescal Wash quartz latite porphyry.

The Temescal Wash quartz latite porphyry crops out along the east side of Temescal Canyon and in two small, isolated bodies east of El Cerrito Village in the northeastern part of the Corona South quadrangle. Pampeyan (1952, p. 21) states that the quartz latite intrudes Bedford Canyon metasedimentary rocks. Clasts of the Temescal Wash quartz latite appear in the Upper Cretaceous conglomerates of the Santa Ana Mountains. Therefore the porphyry is clearly older than the Upper Cretaceous sedimentary rocks and younger than Triassic. Larsen (1948, p. 37) believes the porphyry is probably Jurassic.

In describing the porphyry Pampeyan (1952, p. 22) says:

"Outcrops of the quartz latite are a blue-gray color on weathered surfaces and form rugged, steep cliffs and defiles. . . . Hand specimens of this porphyry vary in texture and also in composition. On the west side (along Temescal Canyon) the rock has a blue-black aphanitic groundmass with abundant phenocrysts of quartz and feldspar that average 2 mm in diameter. To the east the groundmass becomes coarser-grained and the phenocrysts reach an average of 5 mm diameter. The composition varies from dacite to quartz latite by slight changes in the feldspar ratio. Inclusions of the Triassic metamorphics, usually about 25 mm long, are found throughout the porphyry".

Under the microscope a sample of the porphyry collected from a small body exposed in the south quarry of the Temescal Canyon rock quarry displays euhedral phenocrysts of orthoclase and subhedral phenocrysts of plagioclase and quartz. Accessory minerals include hornblende, biotite, and magnetite. Chlorite is present as an alteration mineral after hornblende and biotite. The orthoclase phenocrysts contain inclusions as alterations composed of sericite and chlorite, with a few grains of magnetite. The groundmass is a mosaic of quartz, orthoclase, plagioclase, hornblende, chlorite, and magnetite.

Jurassic-Cretaceous (?) Systems

Corona Hornblende Granodiorite Porphyry

According to Pampeyan (1952, p. 25) a dark rock with slight differences in texture and the composition of granodiorite is found southeast of Home Gardens at the northwest end of Temescal Canyon. In 1948, Larsen (p. 39) called this unit "dark granodiorite prophyry east of Corona".

This granodiorite porphyry crops out in two belts, one on each side of Temescal Canyon, in a small body southeast of El Cerrito Village, and in a rectangular body in the northeastern part of the Corona South

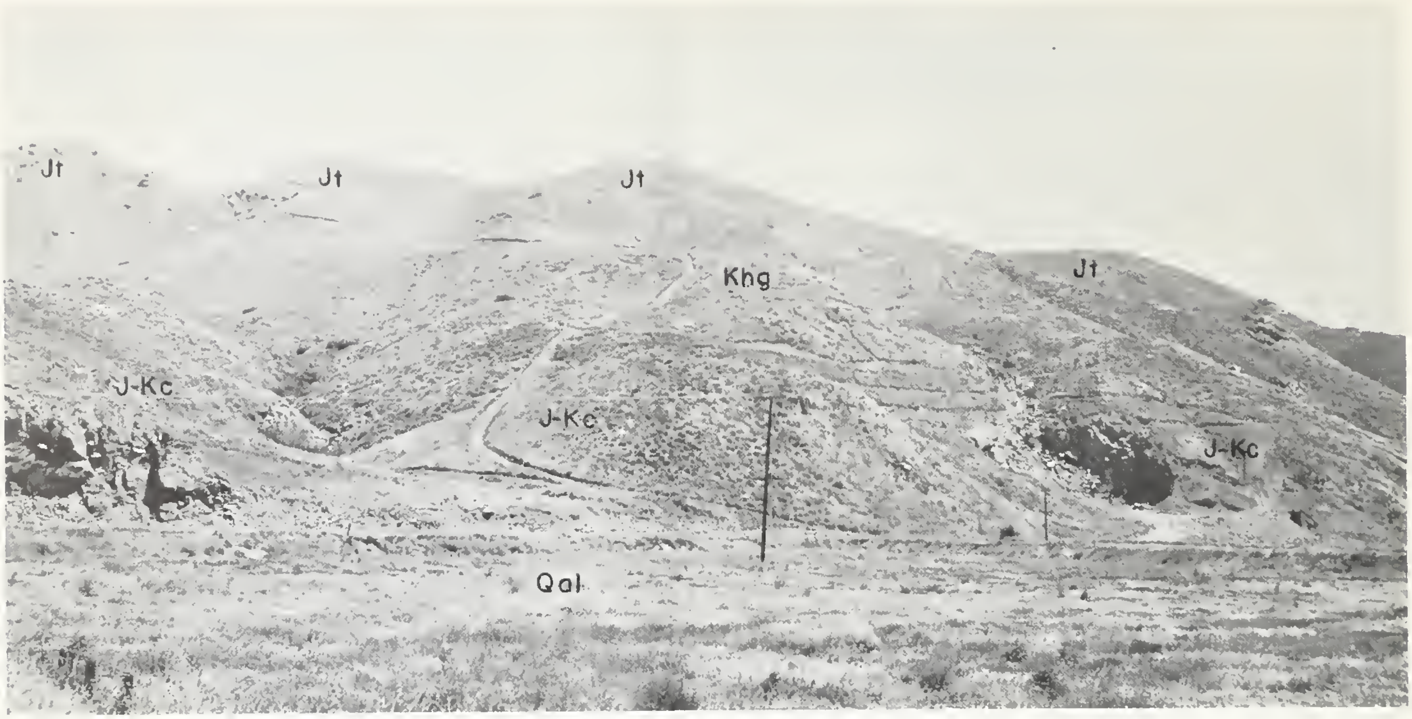

FIGURE 8. Typical topography developed on the intrusive and volcanic rocks in the northeast corner of the Corona South quadrangle. View east from Temescal Wash (foreground). Temescal Wash quartz latite porphyry (Jt), Corona hornblende granodiorite porphyry (J-Kc), Home Gardens quartz monzonite porphyry (Khg), alluvium (Qal). Matich and Sundt Company's Temescal Canyon rock quarries in middle distance.

quadrangle. The two belts are separated by the Cajalco quartz monzonite porphyry. Pampeyan suggests the name "Corona hornblende granodiorite porphyry" and describes the rock as follows:

> "In hand specimen, this rock is characterized by its dark gray color, zoned plagioclase euhedra, and abundant mafic minerals. Texture varies from a true medium-grained granitic rock, with grain size averaging 1 to 2 mm to a porphyritic rock with fine-grained crystalline groundmass grains 0.5 mm in diameter and phenocrysts averaging 5 mm. A typical specimen has about 45 percent plagioclase, 15 percent quartz, 10 percent orthoclase and 20 percent fine-grained groundmass."

Pampeyan believes that the Cajalco quartz monzonite is younger than the Corona hornblende granodiorite porphyry and that the relations with the quartz monzonite show that the granodiorite is clearly pre-Upper Cretaceous.

San Marcos Gabbro

The San Marcos gabbro occurs throughout the Peninsular Ranges province. It forms about one hundred mappable bodies, many of which are very small, in the San Luis Rey, Elsinore, and Corona quadrangles (Larsen, 1948, p. 42). Miller (1947, p. 1397-1426) proposed the name "San Marcos gabbro" for a group of rocks with a wide range of composition and texture found in the San Luis Rey quadrangle. Earlier, Hurlbut (1935, p. 610) used the name "San Marcos Mountain gabbro" for this rock. Larsen (1948, p. 4) used the San Marcos gabbro designation and mapped a body of this rock about 2 square miles in area, west of Glen Ivy along Coldwater Canyon. The west half of this body is within the Corona South quadrangle and the writer, following Larsen, assigns this varied group of dark colored basic intrusive rocks to the San Marcos gabbro.

The San Marcos gabbro body, noted above, is exposed in the southeast corner of the Corona South quadrangle. It is rectangular in plan and extends from Coldwater Canyon northwest nearly to Brown Canyon on the north. On the northeast the body is bounded by the northwest-trending frontal fault of the Santa Ana Mountains, and is in fault contact with Bedford Canyon metasedimentary rocks on its northwest side, but on the southwest it is intrusive into the Bedford Canyon formation. Xenoliths of slate and hornfels are abundant in this body and several large pods of cherty slate are found in Coldwater and Anderson Canyons and along the intervening ridges.

According to Larsen (1948, p. 43) one of the most noticeable features of the San Marcos gabbro in the field is its wide range in composition. Some large bodies consist almost wholly of one rock type; other bodies consist of smaller masses, of contrasting rock types, a few tens of feet or less across. In the Corona area the San Marcos gabbro consists of small bodies of contrasting basic rock types which show gradational contacts.

Most of the San Marcos gabbro in the Corona South quadrangle appears, in hand specimen, to be a dark, medium-grained granitic rock; but in a few outcrops, the feldspars are lath-shaped and surrounded by ferromagnesian minerals. Under the microscope the rocks commonly exhibit a diabasic texture and some a stoutly ophitic texture.

In the vicinity of Coldwater Canyon, the dark-colored gabbro is very resistant and forms rugged steep-walled canyons. To the northwest, the rock is lighter colored and much less resistant, is deeply weathered, and forms light colored rounded slopes which support a dense brush cover.

The San Marcos gabbro in the Corona area includes three principal rock types which are intermixed. Between Coldwater and Anderson Canyons the rock is mostly a coarse-grained hornblende quartz diorite. A typical specimen has about 65 percent plagioclase (labradorite ?), 20 percent hornblende, 10 percent quartz, and 5 percent minor minerals, which include chlorite, biotite, and ores (magnetite and pyrite). Northwest of Anderson Canyon the rock is mainly hypersthene-biotite gabbro, but is in part norite because of local differences in the augite-hypersthene ratio. This gabbro is holocrystalline, coarse-grained, and has a pronounced ophitic texture. The plagioclase feldspar is zoned labradorite in lath-shaped crystals. Minor minerals include augite, both fresh and altered biotite, penninite and ores (magnetite, pyrite). The third rock type is a dark, aphanitic rock with a cryptocrystalline groundmass which contains abundant small inclusions of slate and graywacke, apparently derived from the Bedford Canyon formation. These inclusions are roughly aligned and on weathered surfaces give the rock a flow-banded appearance. This unit is exposed along the northeast margin of the gabbro west of Anderson Canyon and also along the fault contact between the Bedford Canyon formation and the gabbro at its northwest margin. Along this fault a zone several hundred feet wide has somewhat the appearance of a mylonite cataclastic zone.

Larsen reports (1948, p. 43) that the gabbro cuts Triassic Bedford Canyon metasedimentary rocks and the overlying Santiago Peak volcanic rocks and it is in turn cut by various tonalites and granodiorites which he assigned a Cretaceous age. Larsen (1948, p. 43) believed the San Marcos gabbro to be the oldest rock of the Cretaceous (?) southern California batholith. In the Corona area the gabbro intrudes the Bedford Canyon formation of Upper (?) Triassic age and thus is apparently post Triassic. The gabbro in the Corona area is not cut by other batholithic rocks.

Cajalco Quartz Monzonite

The principal mass of the Cajalco quartz monzonite as mapped by Pampeyan (1952, map) lies east of the Corona South quadrangle. However, he also mapped a large dike-like body of quartz monzonite along Temescal Wash. Dudley (1935, p. 502) named these rocks the Cajalco quartz monzonite. Later, Larsen (1948, p. 76) mapped this unit, together with Dudley's Steele Valley granodiorite, as Woodson Mountain granodiorite.

In the Corona South quadrangle, the Cajalco quartz monzonite crops out in a large dike along the west side of Temescal Canyon, as several smaller bodies southeast of Home Gardens, and over a considerable area northwest of Home Gardens. A small part of this last-noted body lies in the quadrangle. Pampeyan (1952, p. 31) reports that the quartz monzonite clearly intrudes the other units found in the Cajalco area and is cut only by the Home Gardens quartz monzonite porphyry and a few mafic dikes and aplite bodies. He believes it can be safely ascribed to the batholith and says of the rock:

"This pinkish to tan massive granitic rock is mildly resistant forming bouldery slopes . . . Mineral composition remains rather constant but three textural varieties were noted; coarse-grained (5 to 6 mm), medium-grained (1 mm), and porphyritic . . . Hand specimens range from pink to gray-white on weathered surfaces and pink to brown-gray when fresh. Megascopically the following mineral percentages were established: white plagioclase, 35 percent; tan to flesh-red orthoclase, 31 percent; pellucid quartz, 29 percent; biotite, 4 percent; epidote, chalcopyrite, etc., 1 percent."

Home Gardens Quartz Monzonite Porphyry

Pampeyan (1952, p. 35) proposed the name "Home Gardens quartz monzonite porphyry" for the dike-like mass of biotite quartz monzonite porphyry exposed for a north-south distance of approximately 2 miles along Temescal Wash, west and northwest of the Minnesota Mining and Manufacturing Company's plant in Temescal Canyon. In 1948, Larsen (p. 90) identified the rock as granodiorite porphyry. Pampeyan reports that the porphyry has intruded Cajalco quartz monzonite but that relations with the Tesmescal Wash quartz latite porphyry and the Corona hornblende granodiorite porphyry are obscure. Nevertheless he believes the Home Gardens porphyry to be clearly late batholith. He describes the rock as follows:

"From a distance the rock is light gray in color, produces rounded boulders and outcrops, and weathers in place to a yellow-brown soil. Textural variations from porphyritic to porphyro-aphanitic are dependent upon the distance from the quartz monzonite contacts . . . Under the hand lens, orthoclase and plagioclase each amounted to 30 percent, quartz 20 percent, groundmass 15 percent, and the remainder biotite."

Micropegmatite Granite

The west margin of a group of low hills, which lie west of Home Gardens and north of State Highway 18, is formed by a pink, indistinctly granular micropegmatite granite which underlies an area of about one square mile (Larsen, 1948, p. 98). This rock crops out over an area only about a tenth of a mile square in the Corona South quadrangle. In outcrops the rock is reddish-brown

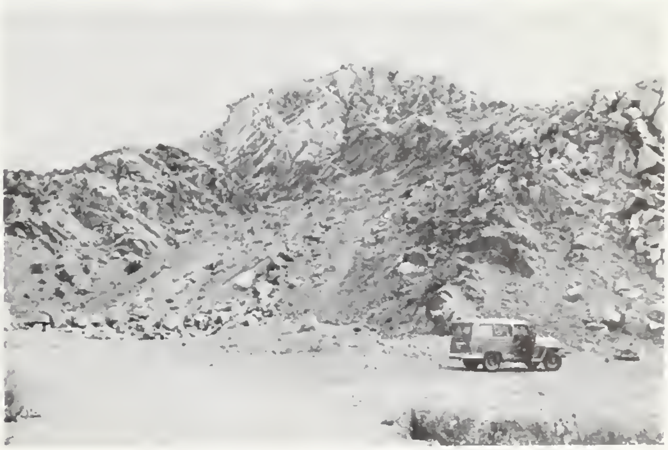

Figure 9. Micropegmatite granite west of Home Gardens at the Jameson quarry. Moderately northeast-dipping northwest-trending sheeting is more strongly developed than the steeply west-dipping north-trending joint system. Observer faces north.

and forms sheet-like masses (fig. 9). It does not weather to form bouldery slopes. In hand specimen the rock is pink and shows feldspar crystals, as much as 3 mm long, scattered in a very fine-grained crystalline groundmass of feldspar and quartz with very little hornblende. This micropegmatite is younger than the Cajalco quartz monzonite but is not in contact with other rocks of the batholith. To the north, near the railroad, the micropegmatite carries inclusions of the Cajalco quartz monzonite and small dikes intrude the monzonite. The micropegmatite granite is apparently late batholith in age and may be approximately related in time to the Home Gardens quartz monzonite porphyry.

Southern California Batholith

According to Larsen (1948, p. 134) the southern California batholith probably covers an area of more than 50,000 square miles. It extends southward from near Riverside, California, for a distance of about 350 miles and averages about 70 miles in width. It is much larger than the batholith of the Sierra Nevada and is commonly believed to be related to that body.

The plutonic igneous rocks of the Corona area, already described, consist of granodiorite porphyry, gabbro, quartz monzonite, quartz monzonite porphyry, and micropegmatite granite, and are all part of the great southern California batholith. Larsen (1948, p. 136) placed the age of the southern California batholith as Lower Cretaceous, but noted that from relations to fossiliferous rocks in northern Baja California, Woodford and Harris (1938) believed the granitic rocks near San Quentin to be early Late Cretaceous in age. Recent determinations by Larsen and others (1954, p. 1277) of the ages of rocks from the batholith of southern California by the lead-alpha activity ratios on the accessory minerals zircon, monazite, and xenotime indicate an average age of 105 million years. This average is based on 25 age determinations made on rocks ranging from quartz diorite to granite. On the basis of rather close agreement between the geologic evidence and the determinations of lead-alpha activity ratios most workers, including Larsen and others (1954, p. 1277) now believe the batholith of southern California to be early Late Cretaceous in age.

Cretaceous System

Trabuco Formation

Poorly consolidated, massive, commonly red, sandy conglomerate crops out along the northeast margin of the Santa Ana Mountains southwest of Corona. It occurs as a rather uniform narrow belt from 400 to 700 feet in width, extending from Tin Mine Canyon to a point northwest of Mabey Canyon and 2½ miles to the northwest is again exposed over a small area on the south side of Santa Ana Canyon. Similar rocks crop out in a small patch in the southwest corner of the Corona South quadrangle between Ladd and Silverado Canyons.

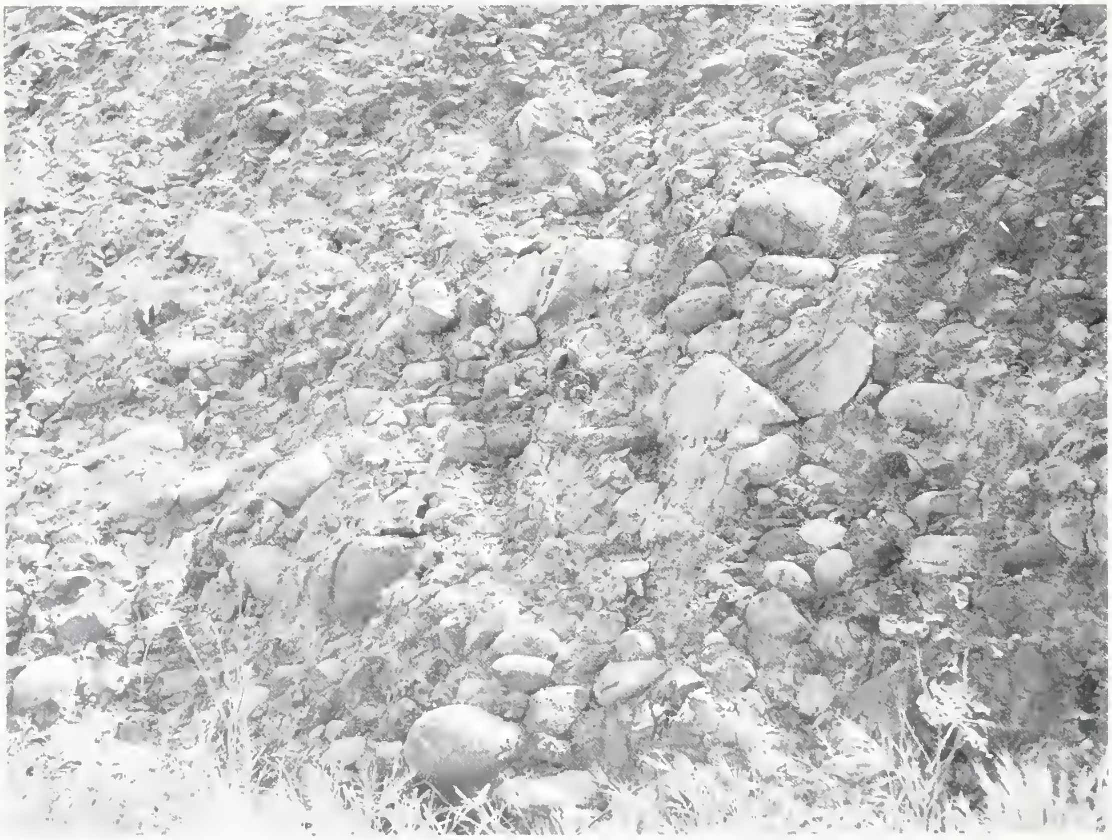

Figure 10. Grayish-green, massive, sandy conglomerate facies of the Trabuco formation composed largely of relatively unweathered cobbles and boulders of grayish-green hornblende andesite from the Santiago Peak volcanics. Exposed in cut along State Highway 18 west of the Elsinore fault. Observer faces south. A second facies, exposed 4 miles southeast, is shown in fig. 11.

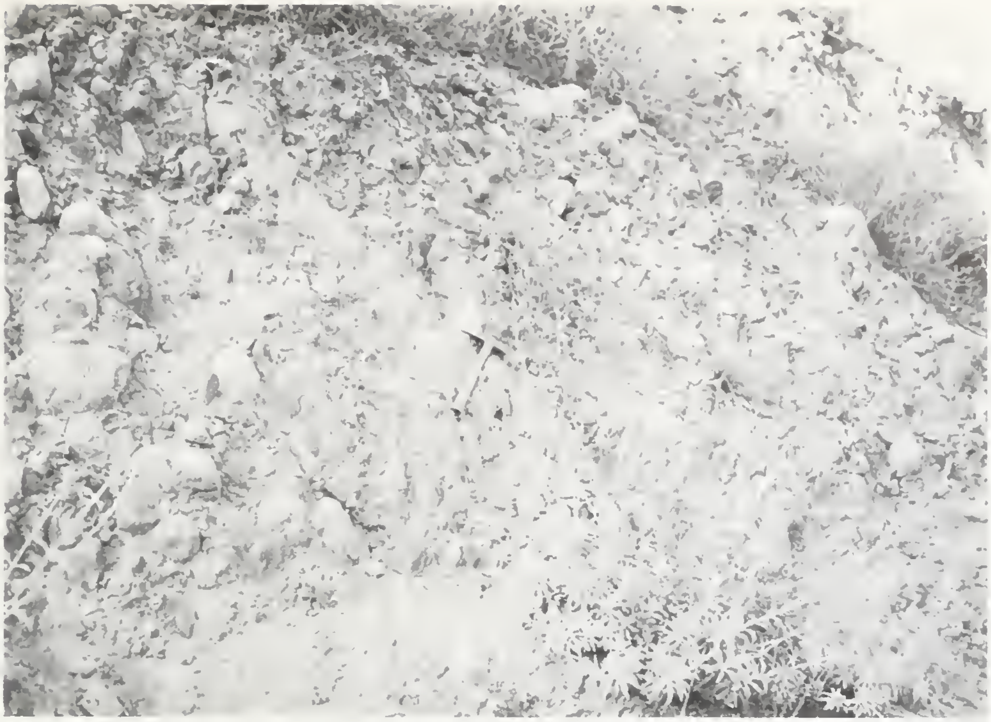

FIGURE 11. Reddish brown to maroon conglomerate and sandstone facies of the Trabuco formation exposed in cut on Skyline Drive, north of Tin Mine Canyon. The cobbles and boulders are mostly thoroughly weathered coarse-grained acid plutonic rocks, and fewer clasts are of green hornblende andesite from the Santiago Peak volcanics. Note sandstone lens marked by hammer. Observer faces north.

Packard (1916, p. 140) proposed the term Trabuco formation as a local name for a poorly consolidated, massive, red conglomerate well-exposed in Trabuco Canyon on the west side of the Santa Ana Mountains. He found no fossils, but thought that the stratigraphic relations of the formation indicated an age only slightly older than that of the overlying Chico group (Upper Cretaceous), probably some phase of the pre-Chico Cretaceous. Woodring and Popenoe (1942, p. 170) in discussing the age of the Trabuco say:

"The Trabuco conglomerate is unfossiliferous; and its precise age is unknown. Structurally it is closely related to the overlying marine Upper Cretaceous beds, and probably is thus of early Upper or late Lower Cretaceous age".

The writer follows Woodring and Popenoe in tentatively assigning a Cretaceous age to beds in the Corona area occurring below fossiliferous marine Upper Cretaceous strata and similar in lithology to the Trabuco formation described from the west flank of the Santa Ana Mountains.

The Trabuco formation (fig. 10) is a rather soft, poorly cemented, massive, sandy boulder conglomerate. The loose cementing causes the conglomerate to weather to a somewhat rounded topography which is in striking contrast to the broken, but abrupt, cliffs ordinarily formed by the more resistant sandstone and conglomerate of the overlying Baker Canyon conglomerate member of the Ladd formation and the higher and generally steeper erosion surface of the volcanic basement rock. The Trabuco conglomerate ranges from brick-red and nearly maroon to buff and light brown with zones of grayish-green. The red color is not constant and appears mainly as streaks in brown or buff material.

The massive conglomerate is very poorly sorted and is composed of cobbles and boulders, as much as three feet in diameter, in a loosely cemented matrix of arkosic grit and sand. Most of the clasts are angular to subangular. The constituents include quartzite, graywacke, limestone, and slate; and granitic and volcanic rocks. The volcanic fragments consist mostly of dark green andesite. Reddish or purple acidic volcanics are less common. The most characteristic large boulders and cobbles are coarse-grained acidic plutonic rocks. These are red, pinkish and reddish-brown in color and show large feldspar phenocrysts. They commonly are deeply weathered and decomposed. Irregular, short lenses, as much as a few tens of feet in length, of medium- to coarse-grained buff to red arkosic sands are present (fig. 11).

As bedding features are uncommon, determinations of the attitude and thickness of the formation are generally only approximate. Along Tin Mine Canyon the Trabuco formation may reach 620 feet in thickness, but it thins to the northwest where it is probably only 400 to 500 feet thick. In general the principal mass of the Trabuco formation in the Corona area averages approximately 550 to 600 feet in thickness and forms a belt, somewhat less than two miles long, which extends northwest from Tin Mine Canyon.

Woodring and Popenoe (1942, p. 167) report that, along the western flank of the Santa Ana Mountains, the Trabuco formation lies on the basement with a profound unconformity but has also, in part, been faulted down together with a mass of underlying basement. Along the northeastern flank of the Santa Ana Mountains, in the Corona area, the conglomerate assigned to the Trabuco formation rests in fault contact against the Jurassic (?) Santiago Peak volcanics. In the southwest corner of the Corona South quadrangle a small exposure of Trabuco formation lies unconformably on the Bedford Canyon formation.

The Trabuco formation, in the Corona South quadrangle between Tin Mine and Wardlow Canyons, appears to grade almost imperceptibly upward into a grayish-green, sandy, basal conglomerate which is assigned to the Baker Canyon conglomerate member of the Ladd formation. To the west, along the northeastern flank of the Santa Ana Mountains, the typical red and brown Trabuco conglomerate evidently lenses or wedges out laterally into the basal conglomerate of the Ladd formation. Because of the gradational and lensing character, both vertically and laterally, the writer is in some doubt as to the validity of the Trabuco formation in the Corona area, and recognizes that these rocks might be part of the Ladd formation. However, in the field, the reddish conglomerate does make a fairly good mappable unit.

J. E. Schoellhamer (oral communication, May 1953) reports that, at one place on the western flank of the mountains, the red Trabuco conglomerate can be seen to grade or interfinger with grayish-green Baker Canyon conglomerate.

In their relations with the overlying Ladd formation, the rocks assigned to the Trabuco formation along the northeastern flank of the Santa Ana Mountains are similar to the Trabuco formation as described by Woodring and Popenoe (1942, p. 170) and by Schoellhamer and others (1954) on the southwest flank of the mountains. No fossils were found in the Trabuco formation. This fact, coupled with the generally angular shape of most of the constituents and the rather unusual red color, leads to the suggestion that the Trabuco sandy conglomerate may be nonmarine in origin. Possibly it represents material carried but a short distance from the east and deposited on a coastal plain.

Ladd Formation

Brownish, massive to thick-bedded conglomerate and sandstone with a brownish-gray sandy siltstone or shale at the top of the succession are exposed along the northeastern flank of the Santa Ana Mountains from Tin Mine Canyon to the Santa Ana River valley. In 1916, Packard (p. 141) referred to the Chico group of Upper Cretaceous age, a sequence of conglomerates, fossiliferous sandstones and shales which he found conformably overlying the Trabuco formation in the western Santa Ana Mountains. Later, Popenoe (1937, p. 380) provided the following generalized section of these rocks.

"Upper Cretaceous

Williams formation:

Pleasants member: Light-colored shaly sandstones with many beds of limy fossiliferous sandstone intercalated. Approximate thickness, 320 feet.

Schulz member: Light-colored, coarse, arkosic sandstones with numerous beds of well-rounded boulders. Unfossiliferous. Average thickness, 200 feet.

Unconformity

Ladd formation:

Holz member: Dark bluish- to brownish-gray micaceous sandy shale or siltstone, with interbedded arkosic sandstones and nonpersistent coarse conglomerate lenses. Fossiliferous in the upper half. Thickness 1,500 feet ±.

Baker member: Gray to brownish, massive to thick-bedded boulder conglomerate below, grading up to shaly arkosic soft brown sandstone above. Sandstone at top highly fossiliferous. Thickness 200 feet ±".

In 1941, Popenoe (p. 742) described the lower member of the Ladd formation as the "Baker conglomerate". Later, Woodring and Popenoe (1942, p. 170) gave the type locality of the Ladd formation as ". . . the region immediately west of the mouth of Ladd Canyon" and reported a measured section of the formation as approximately 1,700 feet thick. At this time the name "Baker Canyon conglomerate member" was adopted for the lower member of the Ladd formation.

Baker Canyon Conglomerate Member

In the Corona area the Baker Canyon conglomerate member is represented by a thickness of about 1,400± feet of brown sandstone and conglomerate which contain a few shaly lenses spaced at irregular intervals. These rocks are exposed in a nearly continuous belt from Tin Mine Canyon northwest to Santa Ana Canyon. The width of outcrop ranges from about 500 feet along the north side of Tin Mine Canyon to nearly 1,600 feet midway between there and Mabey Canyon, shrinking again to about 500 feet on the south side of Santa Ana Canyon. The basal part of the Baker Canyon member is a grayish-green cobble and boulder conglomerate that is somewhat similar to the Trabuco conglomerate. The Baker Canyon conglomerate, however, is better cemented and bedded and shows better sorting. Fewer large boulders are present and they are less weathered. The major rock types are andesites and Bedford Canyon metasedimen-

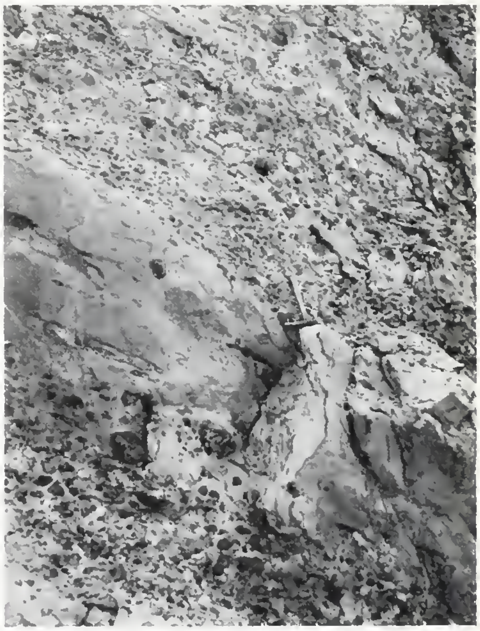

Figure 12. Interbedded sandstone and conglomerate of the Baker Canyon conglomerate member of the Ladd formation. Exposed in cut on State Highway 18 west of the Elsinore fault. Observer faces south.

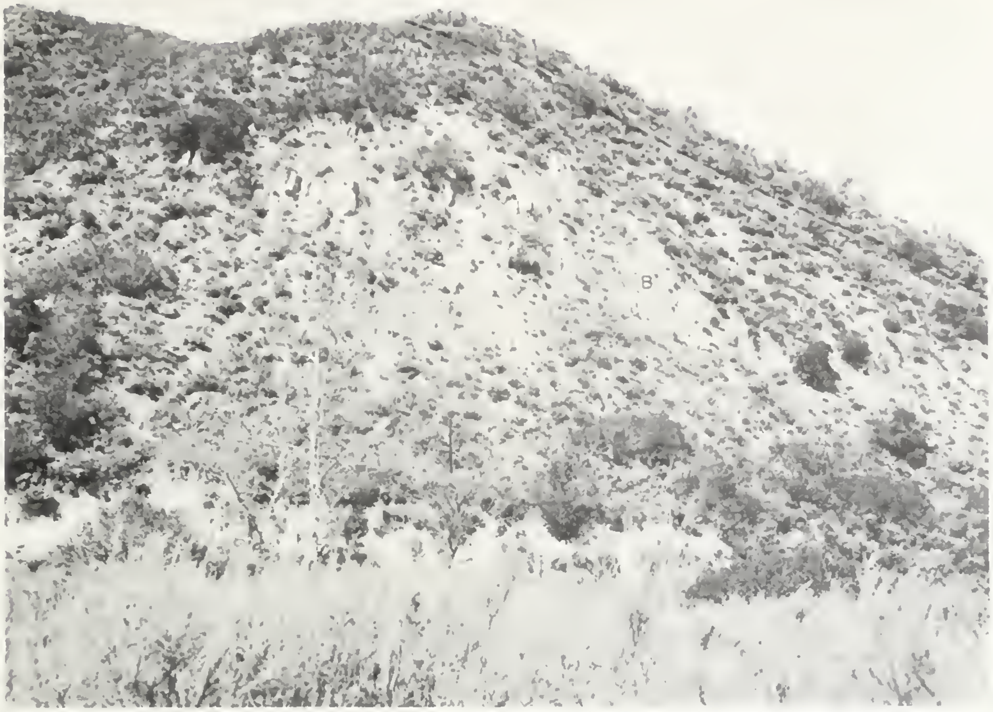

Figure 13. Sandstone of the Baker Canyon conglomerate member of the Ladd formation (B) overlain in fault contact (F) by sandstone and siltstone of the Silverado formation (S). Exposure along north side of Tin Mine Canyon.

tary rocks, but with a few red and gray granitic rocks. These occur in a hard matrix of grayish-green, buff or brown arkosic sand or grit. The Baker Canyon conglomerate grades upward into a sequence of thick-bedded and interbedded buff to gray and brown sandstone and cobble conglomerate (figs. 12, 13) with minor finer-grained silty lenses. The sandstone bodies are mostly arkosic, rather coarse-grained, hard, resistant and massive. They commonly provide a rugged topography of bold and steep cliff faces.

From Tin Mine Canyon to just west of Wardlow Canyon the Baker Canyon member apparently rests with conformable gradational contact on the Trabuco conglomerate. West of the Elsinore fault, along Santa Ana Canyon, Baker Canyon conglomerate and sandstone rest in fault contact on Trabuco conglomerate but a short distance to the southeast Baker Canyon strata rest unconformably on Santiago Peak volcanics. The Baker Canyon conglomerate member is overlain gradationally by the Holz shale member for a short distance east and west of Mabey Canyon, west of Fresno Canyon, and east of Santa Ana Canyon.

Paleontology. Near the top of the Baker Canyon conglomerate member a highly fossiliferous and generally extremely hard sandstone crops out discontinuously from Tin Mine Canyon to the northwest side of Mabey Canyon. Many large specimens of such characteristic Upper Cretaceous forms as *Actaeonella oviformis* Gabb and *Trigonarca californica* Packard were collected. Material from locality 3 was examined by W. P. Popenoe who reported (oral communication, May 1953) it to be the same age as the Baker Canyon sandstone, *Glycymeris pacificus* fauna. The Baker Canyon member is marine and the basal conglomerate may represent the deposits of a transgressing sea.

Holz Shale Member

Dark blue-gray to black and buff marine shale, siltstone and sandy claystone, which crop out in three rather widely separated localities, are assigned to the Holz shale member of the Ladd formation. Between Mabey and Wardlow Canyons a buff to gray sandy claystone crops out, crosses Mabey Canyon and extends about half a mile to the east, along the south side of the canyon. This claystone forms a narrow strip averaging 300 feet or less in width and is characterized by the presence of many large, irregular, very hard limy concretions as much as 3 or 4 feet in diameter. This unit lies immediately above a good fossil locality in the Baker Canyon member and evidently overlies the Baker Canyon sandstone gradationally. At this place the Holz shale is about 200 feet thick and is in fault contact with the overlying Ladd formation, undifferentiated. Extending west from Fresno Canyon for a distance somewhat less than a mile is an outcrop, about 200 feet wide, of Holz shale. It is a gray to buff and light brown sandy shale and siltstone. It apparently overlies the Baker Canyon conglomerate member gradationally and is probably conformably overlain by sandy silt mapped as the Ladd formation, undifferentiated. In this area the contacts above and below the Holz shale are obscured by the lack of marker beds and by impenetrable brush and were mapped as approximate. A small outcrop of blue-gray to black Holz shale is found in Santa Ana Canyon just east of the Elsinore fault. Immediately to the east it is covered by

Genus and species	Fossil localities (shown on plates 1, 3)							
	3[1]*	4*	11*	12*	13*	6*	31[1]**	16[2]**
Megafauna								
Acteonella oviformis Gabb			x		x			
Amauropsis pseudoalveata Packard		x	x		x	x		
Aporrhais cf. A. vetus Packard			x					
Astarte cf. A. lapidis Packard				x				
Baculites cf. B. chicoensis Trask					x			
Calva regina Popenoe					x			
Coralliochama cf. C. orcutti White					x			
Glycymeris pacificus Popenoe		x		x		x		
Lima appressa (?) Gabb				x				
Lima beta Popenoe	x							
Meretrix (?) sp.					x			
Ostrea sp.					x			
Pachydiscus (?) sp.							x	
Panope cf. P. californica Packard					x			
Siphonalia cf. S. dubius Packard			x					
Trigonarca californica Packard	x	x				x		
Trigonarca cf. T. excavata Packard		x				x		
Trigonocallista bowersiana Cooper		x		x	x			
Turritella chicoensis Gabb					x			
Microfauna								
Gaudryina aff. Verneulina munsteri (Reuss)								x
Marsonella oxycona (Reuss)								x

[1] Identified by W. P. Popenoe
[2] Identified by M. O. Israelsky

* Plate 1
** Plate 3

FIGURE 14. Upper Cretaceous faunal list.

a landslide of volcanic material, but does crop out along the highway about a quarter of a mile east of the fault. These Holz beds form a narrow band, with a maximum width of nearly 500 feet and an average width of about 200 feet, that extends eastward for perhaps three-quarters of a mile. Here it is a dark blue to black and gray gypsiferous shale and siltstone, apparently overlying Baker Canyon strata in depositional sequence and in fault contact with Paleocene beds.

Paleontology. The Upper Cretaceous age of the shale assigned to the Holz member is established by the ammonite *Pachydiscus* ? sp. found by D. M. Kinney (oral communication, 1953) west of Fresno Canyon (locality 31). Crushed foraminifera were found along bedding planes of the Holz shale, but little identifiable material was recovered. Fortunately locality 16 (fig. 14) provided two forms which M. C. Israelsky (oral communication, May 1953) identified as in Goudkoff's Cretaceous zone G-1. Goudkoff (1945, p. 960, 991, 992) shows his G-1 zone to be of Upper Cretaceous age, and apparently in the lower part of the Upper Cretaceous.

Ladd Formation, Undifferentiated

A belt of conglomerate, sandstone, siltstone, and shale in the northwest part of the Corona South quadrangle is assigned to the Ladd formation, undifferentiated. These rocks apparently have the same stratigraphic position in space as the Williams formation which in its type area in the northwestern Santa Ana Mountains unconformably overlies the Ladd formation (Popenoe, 1937, p. 380). These rocks are, however, lithologically dissimilar to the Williams formation as defined in the northwestern Santa Ana Mountains by Popenoe (1937, p. 380) and later mapped by Schoellhamer and others (1954) and they seem best placed with the Ladd formation. Rocks designated as "Ladd formation, undifferentiated" crop out in a northwest-trending strip extending from southeast of Mabey Canyon to Fresno Canyon in the Black Star Canyon quadrangle and beyond to a point within half a mile of Santa Ana Canyon. The width of outcrop ranges from about 1,500 feet southeast of Mabey Canyon to nearly 5,000 feet between Wardlow and Fresno Canyons, shrinking again to about 1,200 feet west of Fresno Canyon. This unit probably has a maximum outcrop thickness of about 3,500 feet, although there is some evidence of folding which might substantially reduce the actual thickness.

The Ladd formation, undifferentiated, is composed of buff to gray colored sandstone, cobble and small boulder conglomerate, siltstone and shale. Siltstone forms the major unit but contains beds and lenses of sandstone and conglomerate. The sandstone is white to buff, rather coarse-grained and commonly weakly cemented arkose, although locally it is hard and cliff-forming. The conglomerate is also weakly cemented and consists of clasts of hard volcanic rocks, quartzite, and weathered slate and other metasedimentary rocks, all in a matrix of buff or gray arkose. The metasedimentary clasts are apparently derived from the Bedford Canyon formation. The conglomerate also carries numerous cobbles and boulders of much weathered red and gray, coarse-grained, granitic rocks.

West of Fresno Canyon the rocks mapped as Ladd formation, undifferentiated, rest conformably on the Holz shale member of the Ladd formation, and in this area might be a sandy conglomeratic zone in the upper part of the Holz shale. East of Fresno Canyon, in the Corona South quadrangle, the Ladd formation, undifferentiated, rests with fault contact on Baker Canyon sandstone and conglomerate. Here too, the Ladd formation, undifferentiated, might be part of the Holz shale, although no rocks known to be Holz are exactly similar. The Ladd formation, undifferentiated, is in fault contact with the overlying Paleocene Silverado formation.

Paleontology. No fossils from the Ladd formation, undifferentiated, were collected by the writer. However, during 1956, Donald Lamar (oral communication, Oct. 20, 1956) found fragments at two localities of both straight and coiled cephalopods which indicate a Cretaceous age, although the material is poorly preserved. This material came from the vicinity of the McKnight mine (north line of NW¼ sec. 10, T. 4 S., R. 7 W., S.B.M.) and from a zone about 2,000 feet southwest of the Thomas clay mine (SE¼ sec. 32, T. 3 S., R. 7 W., S.B.M.). Better preserved material, also collected by Lamar, from the Sky Ranch Clay Company mine (East pit) on the north side of Wardlow Canyon (NW¼ sec. 4, T. 4 S., R. 7 W., S.B.M.) yielded the ammonite *Scaphites* sp.

Ladd-Silverado Hiatus

No strata that could be assigned to the Upper Cretaceous Williams formation as described on the western side of the Santa Ana Mountains by Popenoe (1937, p. 380) were found on the eastern flank of the mountains. If the Williams formation was ever present along the northeastern margin of the Santa Ana Mountains it seemingly was early removed by erosion as Paleocene Silverado beds rest on Holz shale, Baker Canyon beds or strata of the Ladd formation, undifferentiated. However, an unconformity was not demonstrated in the field and at every place observed the Silverado formation is faulted against the Ladd formation. Nonetheless the lack of any outcrops of the marine Williams formation and a change to a nonmarine depositional environment for the lower part of the Silverado strata, later described, suggest an unconformity between the Ladd and the Silverado formations. Several miles west of the mapped area, at the crest of the mountains, the Silverado formation lies unconformably on Upper Cretaceous sedimentary rocks (Schoellhamer and others, 1954, p. 69).

Tertiary System

Paleocene Rocks

Silverado Formation

Brown to reddish-brown or white to greenish-gray and gray sandstone which is locally clay-bearing and contains quartz-rich facies, conglomerate, siltstone and silty claystone (figs. 15-20) crop out in a broad, but irregular band, extending across the area from just east of Bedford Canyon to Santa Ana Canyon. These strata have been assigned a Paleocene age on faunal and lithologic evidence. The Paleocene strata in the Corona region include sediments similar to those of the Eocene Ione formation of the western Sierra Nevada foothills. The distinctive sedimentary rocks of both formations include clays and quartz-rich standstone of economic importance and anauxite-bearing sandstone.

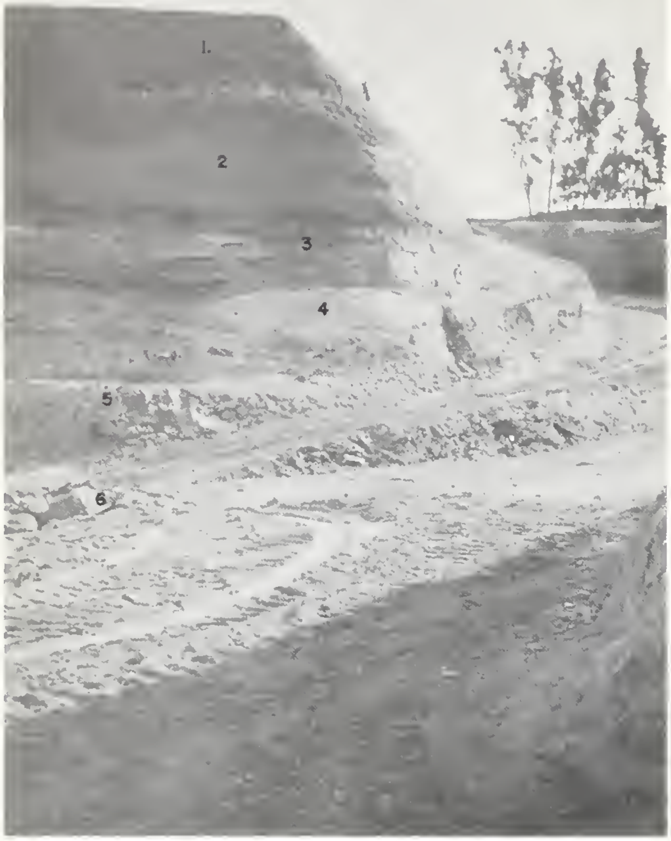

Figure 15. Exposure of Silverado formation sandstone and clay at the Bedford Canyon clay mine of Gladding, McBean and Company. Hornblende diorite (6), a phase of the Corona hornblende diorite porphyry, is overlain by residual red mottled clay (5), arkosic sandstone (4), sedimentary red mottled clay (3), coarse arkosic sandstone (2), and sandy older alluvium (1). Observer faces southwest. *Photograph by George B. Cleveland.*

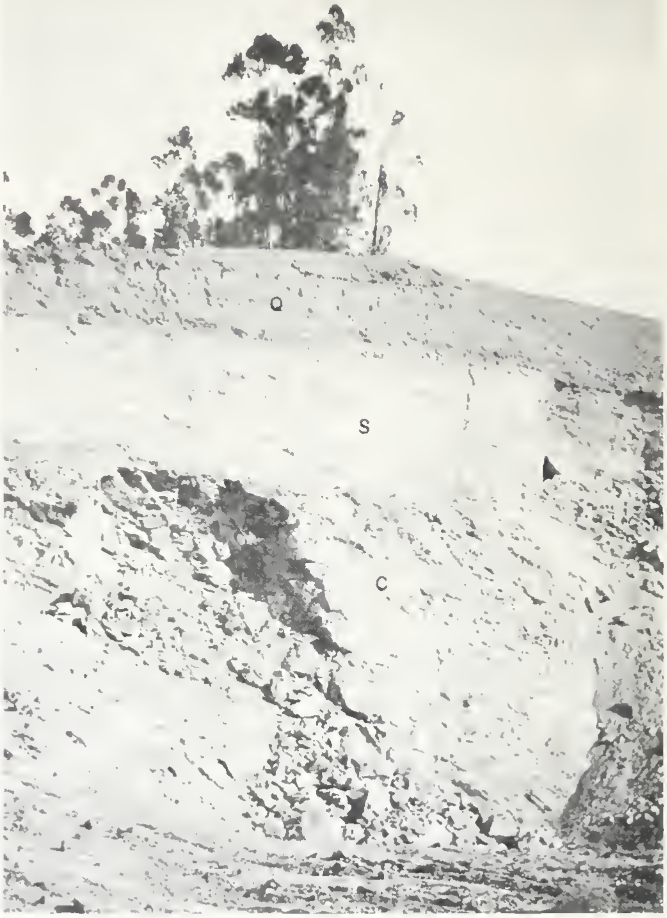

Figure 16. Another exposure of sandstone and clay of the Silverado formation at the Bedford Canyon clay mine. Sedimentary red mottled clay (C) is overlain by white to buff arkosic sandstone (S). Brown older alluvium (Q) covers the Silverado strata. Observer faces east. *Photograph by George B. Cleveland.*

Dickerson (1914, p. 263) assigned a succession of fossiliferous sedimentary rocks in the Santa Ana Mountains to the Martinez formation, then called lower Eocene. He reported these rocks to be unconformably overlying the Chico group (Upper Cretaceous). Later, English (1926, p. 19) mapped more completely the occurrences of these strata in the northern part of the Santa Ana Mountains. In 1935, Sutherland (p. 76) assigned to the Martinez formation clay-bearing sandstone, shale, and conglomerate southwest of Corona. Woodring and Popenoe (1945) proposed the name Silverado formation for these Paleocene strata because ". . . it is undesirable and generally impracticable to attempt to combine lithologic and age concepts in stratigraphic nomenclatures . . .". The type region was designated as the area northeast of Irvine Park on the west side of the mountains. The writer follows Woodring and Popenoe in assigning Paleocene strata in the Corona area to the Silverado formation.

Along the northeastern flank of the Santa Ana Mountains the Silverado formation rests in fault contact with the Ladd formation or the Santiago Peak volcanics but in Temescal Wash it rests depositionally on intrusive rocks or on residual clay derived from the intrusive rocks. From Santa Ana Canyon to a locality a short distance east of Fresno Canyon the Silverado formation is overlain conformably by the Santiago formation. West of Wardlow Canyon, it is overlain in fault contact by the Vaqueros and Sespe formations, undifferentiated.

Sedimentary rocks in the mapped area assigned to the Silverado formation form a strip parallel to the mountains and ranging in width from less than 500 feet east of Bedford Canyon to a maximum of 2,500 feet between Main Street and Tin Mine Canyons and narrowing to 1,750 feet at Santa Ana Canyon. The maximum true thickness may approach 2,000 feet west of Wardlow Wash. In lower Bedford Wash, in the eastern part of the Corona South quadrangle, the Silverado formation has a maximum thickness of about 200 feet as indicated by drill hole data. Generally poor bedding and the lack of good marker beds, however, make the determination of attitudes and thickness difficult and unreliable. Complex faulting also greatly complicates the thickness

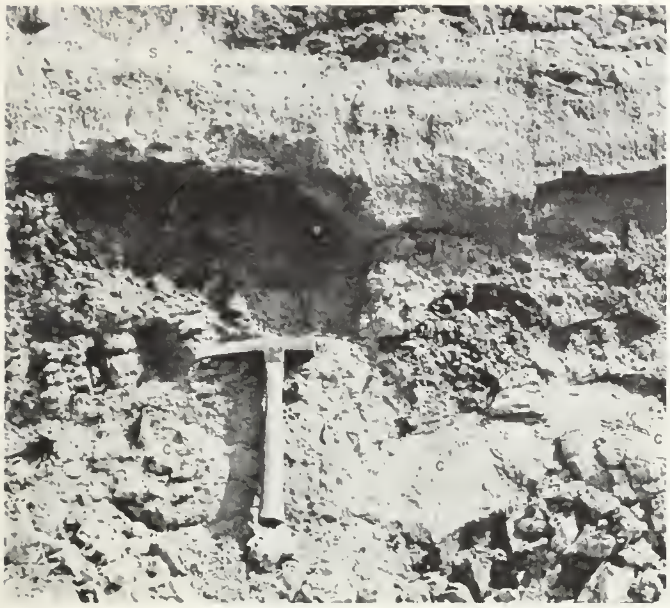

FIGURE 17. Residual red mottled clay (mapped with Silverado formation) exposed along northwest side of Bedford Canyon clay mine. Red mottled residual clay (C) is overlain by buff, medium- to coarse-grained arkosic sandstone (S) with a thin, discontinuous, pebble conglomerate at base (marked by hammer head); contact is very irregular. Dark lens-shaped bodies (L) are red mottled clay clasts in the sandstone. Observer faces northwest.

problem. Moreover, the section may be repeated by folding. Undoubtedly both marine and nonmarine beds are present, apparently interfingering in a complex pattern which has been further complicated by faulting. The presence of local clay beds with lignite seams in poorly sorted, cross-bedded, coarse-grained arkose and a few fresh- and brackish-water fossils indicate a nonmarine depositional environment for the lower part of the formation. Marine fossils in hard lenses and in calcareous concretions in moderately well sorted sandstone and siltstone indicate marine deposition for the upper part of the formation.

The lithologic and faunal evidence suggest that probably the Silverado formation was deposited under lagoonal and near-shore conditions along a coast of very moderate relief. For purposes of discussion, the formation is divided into two members: a lower nonmarine fresh or brackish water unit and an upper marine unit. This is done primarily on lithologic grounds, but also in part is based on stratigraphic position. These members, however, are not delineated on the geologic map as no adequate marker beds or other criteria were found in the field to facilitate mapping the two members. Thicknesses of the two members could not be measured, but the marine member may represent most of the Paleocene strata.

Nonmarine (Lower) Member

The basal part of the Silverado formation in general seems to be nonmarine or lagoonal. It contains large quantities of alumina-rich clay and small amounts of bauxitic clay and high-silica "bauxite". Mining operations have developed several of the clay deposits and a quartz sand deposit which has been for many years the principal source of sand used by the glass making industry of southern California. This unit shows a rather uniform composition from just east of Bedford Canyon to Mabey Canyon, and generally has a thickness of 200 feet or less. Locally it is as much as 500 feet thick.

The lower member is characterized by reddish-brown to greenish-buff clayey sandstone, siltstone, or claystone which commonly contain abundant plates of green to greenish-black and grayish-green mica (biotite and chlorite) and pearly gray anauxite (clay mineral formed by the alteration of biotite). In places in the sandstone and siltstone these platy minerals are so numerous and well aligned as to give the rocks a schistose or foliated appearance like that of a decomposed mica schist. The siltstone and claystone are generally thinly laminated and fissile. Similar micaceous and fissile siltstone crops out for a short distance east of Santa Ana Canyon. Scattered lensing seams of lignite occur in the alumina-rich clay zones, near the base of the Silverado strata.

Locally the basal part of the lower member of the Silverado formation is a thin red cobble conglomerate. On the east side of Hagador Canyon and near Santa Ana Canyon this conglomerate is probably about twenty feet thick. It consists of small to medium cobbles set in a matrix of reddish-buff to gray arkosic grit and is rather well indurated. The cobbles are mostly sub-rounded; many are hard metamorphic and volcanic rocks; granitic clasts are rarer and generally decomposed.

The lower member contains the 1- to 10-foot thick (perhaps as much as 30 feet thick in places) economic sedimentary clay beds of the Silverado formation. These beds consist of relatively high-grade, reddish-brown pisolitic sandy clay, red mottled clay, and white to brownish-gray conchoidally-fracturing kaolinite. In general, however, the clay does not have the yellowish to gray or brownish-gray to olive brown color and similarly colored abundant pisolities of the true Claymont clay bed described by Sutherland (1935, pp. 79-81) and Woodring and Popenoe (1945) in the western and northwestern Santa Ana Mountains. Woodring and Popenoe (1945) named the Claymont clay bed with the type locality on the Claymont property of Gladding, McBean and Company near the crest of the divide at the head of Coal Canyon, about two miles south of the west end of the Santa Ana narrows map area. In the Corona South quadrangle pisolitic clay, somewhat similar to the Claymont clay bed, crops out in a few places between Wardlow and Hagador Canyons, in isolated outcrops between Hagador and Main Street Canyons, in one small exposure on the east side of Bedford Canyon, and in a clay pit in lower Bedford Wash opened by Gladding, McBean and Company in 1955. Drilling indicates this pisolitic clay zone underlies a large part of lower Bedford Wash. The pisolitic clay evidently occurs only as pockets or lenses within buff or gray sandy claystones and red mottled clay which form the bulk of the clay deposits. All of the occurrences of pisolitic clay appear to be near or at the base of the Silverado formation but poor exposures make measuring sections impractical. According to Woodring and Popenoe (1945) the Claymont clay bed is 65 to 140 feet above the base of the Silverado formation in measured sections a few miles west and southwest of the Corona area. Gray to black, finely disseminated carbon in various proportions is associated with the clays and in some places is concentrated in lenses or

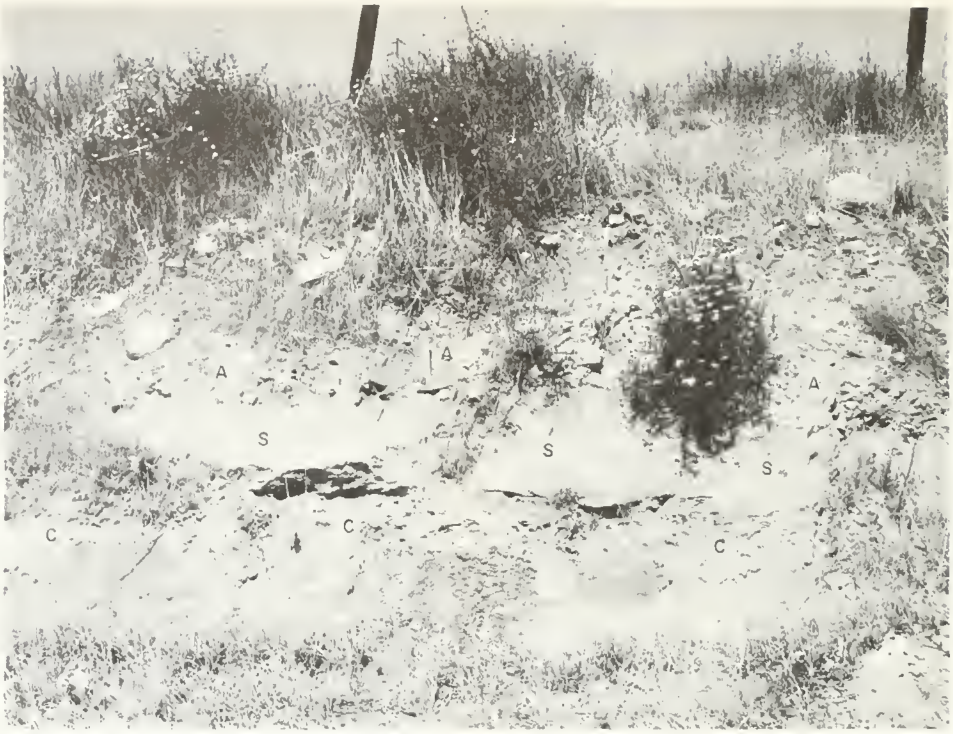

FIGURE 18. Gently dipping gray micaceous sandstone (S) and dark red mottled sandy clay (C) of the Silverado formation overlain by older alluvium (A), contact marked by hammer. Exposed 7 miles southeast of Corona in cut on State Highway 71. Observer faces west.

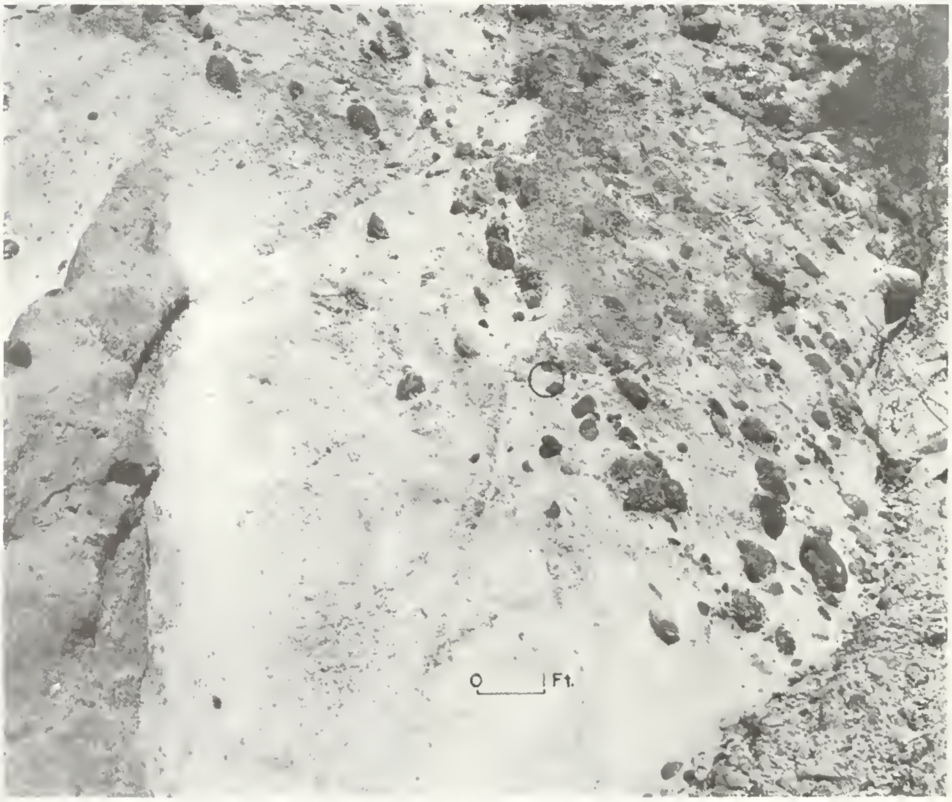

FIGURE 19. Typical Silverado formation conglomeratic sandstone. Exposure along east side of Hagador Canyon. Quarter (in circle) gives scale. Observer faces east.

pockets of soft coal. The clay beds in general have little continuity and are not necessarily connected to one another. Whether or not the clay beds are repeated by folding and faulting, or are original pockets that appear intermittently both horizontally and vertically in the basal part of the sequence is not known. Whatever the original disposition of the clays, they are now so disturbed by faulting and probably by folding in most places that mining operations are indeed difficult. These clays, more fully described under economic geology, are believed to be derived from transported material which originally formed in place as a residual weathered deposit. The clay beds are ordinarily overlain by gray to buff shale which at many places is stained red or pink by iron oxide. In addition to the higher-grade clays, brick-red to reddish-brown or orange-brown and gray sandy clays are abundantly exposed.

Red mottled clay ranging in thickness from 5 to 20 feet, with a discontinuous, but as much as 4-foot-thick pisolitic zone at the top, is exposed in the Gladding, McBean and Company pit in Lower Bedford Wash. This lower zone of red mottled clay is residual in origin and grades downward into the unaltered Corona hornblende granodiorite porphyry. The top of the residual clay is an undulating erosion surface which is overlain by a thin zone, 5 to 15 feet thick, of tawny to buff colored, coarse, weakly indurated arkose which contains much mica and abundant pearly gray anauxite. Red mottled sedimentary clay ranging from 10 to 15 feet in thickness overlies the arkose. The top of the sedimentary clay is a gray to buff or tawny colored pisolitic zone from 1 to 5 feet thick which in places is bleached to nearly white. The sedimentary clay sequence is overlain by 10 to 100 feet of buff to gray and white coarse arkose which contains abundant grayish-green mica and pearly gray anauxite. (See figs. 15, 16, 17.)

East of Bedford Wash and along both sides of State Highway 71 gently dipping, coarse, poorly consolidated and rather pure, white quartz sandstone apparently represents the lowest part of the Silverado formation in that area. This sandstone is distinctive as, in general, it contains numerous green to greenish-black and grayish-green mica plates and pearly gray anauxite plates and in a few places has somewhat of a schistose appearance. Where this sandstone is well-exposed in the Owens-Illinois Glass Company quarry west of the highway, however, it ranges widely in composition and contains lenses of grayish-green sandy clay and micaceous fissile silty claystone as well as mica-free pockets. The sandstone is coarse-grained, thin-bedded and locally cross-bedded. Some of it is poorly sorted and contains scattered smooth and rounded walnut-sized pebbles. A water well (No. 1, fig. 45, Mineral Deposits Section) is reported to have penetrated about 100 feet of these sedimentary rocks and bottomed in hard bedrock. Apparently the bedrock is a very feldspathic biotite diorite with a marked planar structure as is shown by a dimensional alignment of the feldspar laths and apparently also by the mica. A second water well (No. 2, fig. 45, Mineral Deposits Section) is reported to have gone 325 feet in loose sands and to have bottomed in biotite quartz monzonite (oral communication, A. O. Woodford, May 1953). This silica-rich sandstone is believed to represent the basal part of the Silverado formation in the Temescal Canyon part of the area because it rests on igneous basement rocks or on a thin red mottled residual clay zone. However, it is not necessarily equivalent to the basal clay-bearing member which crops out to the northwest along the margin of the Santa Ana Mountains and probably is equivalent in age to the strata that lie just above the lowermost sandy clay and sedimentary red mottled clay zones.

Marine (?) (Upper) Member

Above the basal unit the Silverado formation is generally a coarse, weakly indurated, white to gray and yellow-brown to buff and tawny unit composed of siltstone, sandstone, conglomeratic sand, and conglomerate. This unit crops out from Bedford Canyon to Santa Ana Canyon, and reaches a maximum outcrop width west of Wardlow Wash where it probably has a thickness of 1,500 to 2,000 feet.

The conglomerate is composed mostly of subrounded cobbles of volcanic rocks but includes rarer metamorphic and granitic cobbles and a few sedimentary rocks in an arkosic matrix. It locally contains boulders as much as 3 feet in diameter. The conglomerate in general appears to form lenses in the sand or sandstone. A pebble count made at a locality just east of the south edge of Santa Ana Canyon from a 2- by 3-foot surface of a well-indurated large pebble and small-cobble conglomerate yielded the following:

Rock type	Number	Percent
Granite or quartz monzonite	6	6
Granite or quartz monzonite aplite	10	11
Total plutonic	16	17
Rhyolite or quartz latite	25	27
Andesite	33	35
Total volcanic	58	62
Quartzite	2	2
Indeterminate metamorphic	1	1
Granite or quartz monzonite gneiss	12	13
Total metamorphic	15	16
Sandstone	5	5
Total sedimentary	5	5
Grand total	94	100

This pebble count is typical of much of the Paleocene conglomerate along the northeastern flank of the Santa Ana Mountains. The high percentage of red and purple volcanic clasts in this conglomerate is suggestive of the upper Eocene to lower Miocene Sespe formation described elsewhere in this report. However, the stratigraphic relations of these beds strongly suggest a Paleocene age.

The lowermost sand and sandstone unit of the upper member of the Silverado formation is characterized by numerous angular clasts of siltstone which contain much grayish-green mica. Evidently the siltstone clasts represent a reworking of micaceous siltstone from the lower member, probably when the change from nonmarine to marine deposition occurred. Although no line can be drawn in the field to mark this change, the beds assigned to the upper member are believed in general to represent marine sedimentation, as these rocks are moderately well sorted and bedded and in a few places contain marine fossils in hard, somewhat limy lenses and in calcareous concretions.

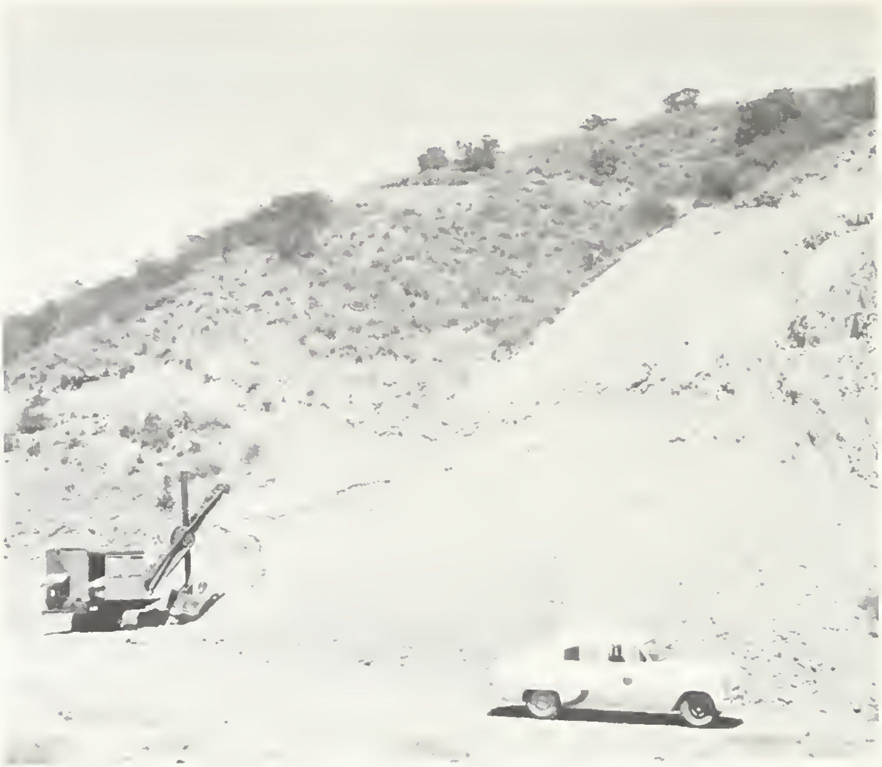

FIGURE 20. Vertical siltstone and claystone of the Silverado formation. Exposure at the Thomas clay deposit, east pit, west of Wardlow Wash. Observer faces east.

Buff to brown and gray silty claystone irregularly intercalated with clayey siltstone comprise the upper part of the upper member. These beds are somewhat fissile and commonly contain abundant mica plates, but do not have the "schistose" appearance that is typical of the lower member, previously described. The claystone and siltstone appear to occur in lenticular bodies although they may have thicknesses of from 500 to 1,000 feet. Their exact stratigraphic position is not known, but along the east side of Fresno Canyon they seem to

Genus and species	Fossil localities (shown on plates 1, 3)					
	2[1]**	7*	8*	9[2]*	10[2]*	29[3]*
Brachysphingus ? sp.	x					
Crassatella branneri ? Waring	x					
Crassatellites ? sp.				x		
Glycymeris veatchii major Stanton	x					
Ostrea sp.			x			
Pholadomya sp.		x				
Priscoficus robustus ? (Weaver)	x					
Surcula merriami ? Dickerson	x					
Tellina ? sp.				x		
Turritella infragranulata ? Gabb	x			x		
Turritella pachecoensis Stanton	x			x		
Turritella cf. T. pachecoensis Stanton						x
Venericardia ? sp.					x	

[1] Identified by W. P. Popenoe
[2] Checked by J. G. Vedder
[3] Identified by Ralph B. Stewart

* Plate 1
** Plate 3

FIGURE 21. Paleocene faunal list.

be in the uppermost part of the sequence. The stratigraphic sequence from bottom to top of the upper member of the Silverado formation is not exposed. Scattered bits of circumstantial evidence, however, suggest a lower sandstone, a middle conglomeratic sandstone and an upper sandstone and siltstone.

Numerous exposures of brick-red or reddish brown sandy clay are found in the upper member, apparently at several stratigraphic positions. In general these clays are confined to narrow zones and do not appear to be lithologically the same as those of the lower member. Most of these clay exposures are along minor faults and are interpreted as fault gouge.

Paleontology. Fossils were collected from the Silverado formation at several localities (fig. 21) and, of the species identified, *Turritella pachecoensis* Stanton is the principal guide fossil. W. P. Popenoe examined a collection made by J. E. Schoellhamer at locality 2 south of Santa Ana Canyon in the west part of the Santa Ana narrows map area (pl. 3) and reported the age as Paleocene. Several well preserved Turritellas were collected by the writer and R. F. Yerkes from a large limy concretion intercalated with fissile claystone in the Thomas clay deposit west pit (locality 29). These specimens were identified as *Turritella* cf. *pachecoensis* Stanton by Ralph B. Stewart, Paleontology and Stratigraphy Branch, U. S. Geological Survey, (oral communication, J. E. Schoellhamer, March 1955). Although the specimens are incomplete, Stewart found them better preserved than the type specimen from Pacheco, and placed the modifying cf. in the identification.

Eocene Rocks

Santiago Formation

Eocene rocks do not crop out in the Corona South quadrangle but are present in the adjoining Santa Ana narrows map area two-fifths of a mile to the west. Woodring and Popenoe (1945) named sedimentary rocks of Eocene age a few miles to the west in the northwestern Santa Ana Mountains the Santiago formation. These Eocene deposits were earlier called the Tejon formation by Dickerson (1914, pp. 257-274) and also by English (1926, pp. 19-22).

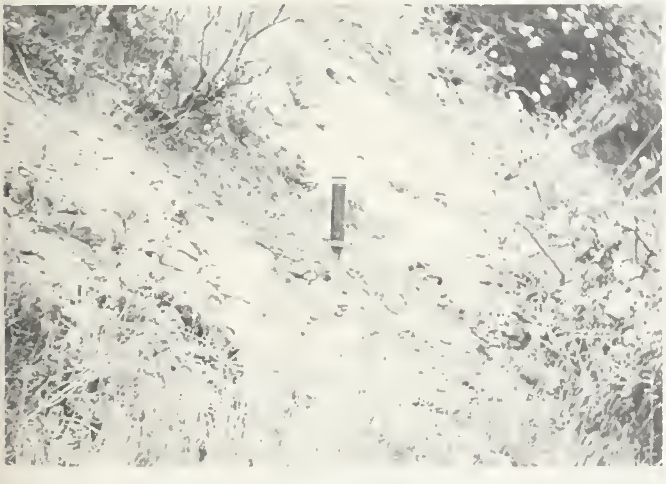

FIGURE 22. Interbedded sandstone and siltstone of the Santiago formation. Exposed in cut on State Highway 18, a third of a mile east of Green River Camp. Observer faces south.

A band of Eocene (?) sandstone, siltstone, and cobble conglomerate, ranging from 200 to 800 feet in width, extends for about 1¾ miles southeast from Santa Ana Canyon across Fresno Canyon, along the northeast margin of the Black Star Canyon quadrangle. Fossil evidence at two localities, collected by other workers, indicates the Eocene age of these beds. Also, these rocks are lithologically similar to those of the Santiago formation mapped by Schoellhamer and others (1954) to the west in the Santa Ana Mountains. These beds, however, are separated only tentatively from the Paleocene rocks on the Santa Ana narrows area geologic map. The Eocene age is based on conflicting and somewhat indefinite faunal evidence, discussed below, and no continuous marker beds suitable for separating the Paleocene and Eocene rocks were found, but on the east side of Fresno Canyon and east of State Highway 18 a well-cemented cobble conglomerate may mark the base of the Eocene beds.

The Santiago formation apparently rests with conformable, gradational contact on strata of the Silverado formation and is conformably overlain by the Vaqueros and Sespe formations, undifferentiated (fig. 24).

Paleontology. At the east margin of Santa Ana Canyon, just east of State Highway 18, fossil locality 1 is in a hard, limy bed within a weakly cemented siltstone which also contains locality 15. About 20 poorly preserved impressions of mollusks were collected at locality 1, and possibly belong to the fauna of the Santiago formation. M. C. Israelsky examined a microfauna from locality 15 and reported: "Zone A-1 or A-2 of Goudkoff. We may assume it is above the *Siphogenerinoides* zone. On a negative basis it may be A-2". Goudkoff (1945, p. 956-983) indicates that he considers the A-1 and A-2 zones to be pre-Martinez Paleocene, and that the A-2 zone is immediately above the Upper Cretaceous. The *Siphogenerinoides* zone does not extend above the Upper Cretaceous.

W. P. Popenoe examined material collected by G. S. Hilton (1950, map, locality 95) at a locality approximately half a mile east of locality 1. Unfortunately the writer was unable to recover this locality. However, Popenoe (oral communication, 1953) reports two mollusks, *Ampullina* ? sp. indeterminate and *Plagiocardium brewerii* ? (Gabb), and says:

"Probably middle Eocene—exact horizon not determinable. I should consider it as neither Cretaceous or Paleocene, but probably somewhere in the middle Eocene. There is nothing like the pelecypod listed above from the Cretaceous, but these are common in the Eocene".

A second locality also not visited by the writer, but reported to be about half a mile east of Fresno Canyon, yielded specimens which, according to J. E. Schoellhamer (oral communication, 1957) are tentatively identified as *Turritella buwaldana.* In the Los Angeles Basin this Turritella is listed by Natland and Rothwell (1954, p. 40) as an Eocene guide fossil.

Upper Eocene to Lower Miocene Rocks

Vaqueros and Sespe Formations, Undifferentiated

Maroon, red, buff, gray and grayish-green, coarse sandstone and conglomerate, fossiliferous in a few places, and containing a minor amount of siltstone, crop out in discontinuous patches from the southeastern extremity of the area to Scully Hill, north of Santa Ana Canyon. On lithologic and faunal evidence these rocks are assigned to the nonfossiliferous Sespe formation and the fossiliferous marine Vaqueros formation. They are mapped as the Vaqueros and Sespe formations, undifferentiated, as the Sespe strata grade both upward and laterally into the Vaqueros strata. These two formations are commonly mapped as a single undifferentiated unit elsewhere in the northwestern Santa Ana Mountains (English, 1926; Woodring and Popenoe, 1945; Schoellhamer and others, 1954).

W. L. Watts in 1897 designated as the Sespe brownstone formation rocks of continental origin that occur in the region of Sespe Creek, Ventura County. In 1924, W. S. W. Kew changed the term to Sespe formation. The Sespe formation was recognized in the northwestern Santa Ana Mountains by English (1926) and later also was described by Woodring and Popenoe (1945). The Sespe beds in the Santa Ana Mountains have yielded no fossils, but probably range in age from late Eocene to earliest Miocene (Woodford and others, 1954, p. 69).

In 1904, H. Hamlin applied the name Vaquero sandstone to fossiliferous marine sandstone in an area in Monterey County, California. Dickerson (1914) listed a Vaqueros fauna from the Santa Ana Mountains. Later, Loel and Corey (1932, pp. 51-60) described the Vaqueros fauna of the Santa Ana Mountains more completely. H. G. Schenck in 1935 redefined the formation and suggested the term Vaqueros group. In the Santa Ana Mountains the Vaqueros formation of early Miocene age overlies the Sespe formation and also intertongues with it (Woodford and others, 1954, p. 69).

In the Corona area the Sespe and Vaqueros formations of nonmarine and marine strata so intricately interfinger that the writer was unable to map them as separate units. The nonfossiliferous and apparently nonmarine Sespe formation is recognized on a lithologic basis, whereas the presence of probable Vaqueros beds is indicated by lithology and by fossil locality 5 which yielded a large assemblage of poorly preserved marine megafossils. These fossils, which include many fragments of thick-shelled oysters, are contained in a weakly cemented, buff, fine-grained sandstone bed which averages 2 feet in thickness and is exposed for about 200 feet. Precise identifications have not been made but the collection as a whole indicates an early Miocene or lower middle Miocene age (oral communication J. G. Vedder, Jan. 1957).

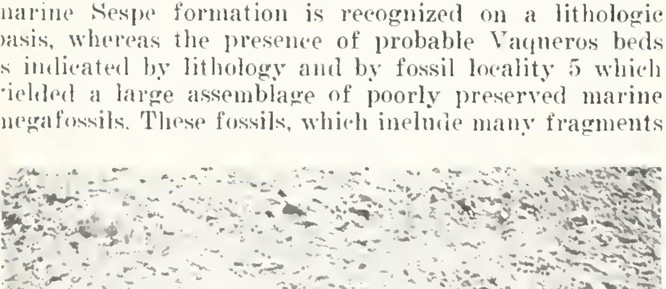

Figure 23. Red conglomerate of the Vaqueros and Sespe formations, undifferentiated. Exposed in cut on State Highway 18, five-eighths of a mile east of Green River Camp. Observer faces northwest.

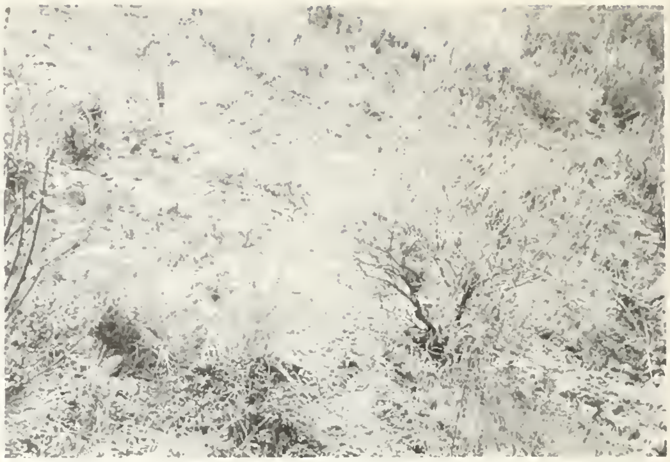

Figure 24. Depositional contact (marked by hammer) between conglomerate of the Vaqueros and Sespe formations, undifferentiated and Santiago formation siltstone. Beds dip steeply to the left. Roadcut on State Highway 18 half a mile east of Green River Camp. Observer faces southeast.

Most of the area between Brown Canyon and Bedford Canyon is underlain by Vaqueros-Sespe red to maroon, white or grayish-green conglomeratic sandstone and minor beds of buff siltstone. On the south these rocks rest in fault contact against metasedimentary rocks of the Bedford Canyon formation. They apparently conformably overlie Paleocene sandstone on the northeast. The driller's log from well No. 4 (fig. 45, Mineral Deposits Section) indicates that nearly 1,000 feet of flatlying Vaqueros-Sespe strata were penetrated before entering probable Paleocene strata.

In the Santa Ana narows area (fig. 24) Vaqueros-Sespe strata apparently rest unconformably on the Santiago formation and are in fault contact against the Silverado formation west of Wardlow Wash. East of Fresno Canyon Vaqueros-Sespe beds are overlain in fault contact by platy shale, sandstone and conglomerate of the upper Miocene Puente formation. Vaqueros-Sespe beds are also exposed along the southern margin of Scully Hill. At one place there they lie conformably below middle Miocene Topanga sandstone and there is a small sliver resting in fault contact with Topanga beds.

Weakly indurated massive, gray to grayish-green, maroon and reddish sandstone, siltstone, conglomerate, and conglomeratic sandstone crop out continuously from Wardlow Wash west to Fresno Canyon and continue west of Fresno Canyon for nearly half a mile and thence extend beneath terrace deposits. These strata show a maximum exposed thickness of 2,300 feet at a locality east of Fresno Canyon. Generally indistinct bedding and discordant attitudes make the calculation of thickness difficult. Vaqueros-Sespe beds also are exposed in the road cut along State Highway 18 southwest of Prado Dam. Here this unit consists of a massive, red to red-brown cobble and boulder conglomerate (fig. 23) but to the north and also to the west on Scully Hill across the Santa Ana River it is mostly a very weakly indurated red arkosic sandstone with conglomeratic lenses. The red sandstone here, and eastward to Wardlow Wash, and the red to grayish-green sandstone east of Bedford Canyon resemble Sespe strata a few miles to the west and southwest where the Sespe formation is well exposed and has been mapped by Schoellhamer and others (1954). The conglomerate is characterized by rounded to subrounded cobbles and boulders of red and dark purple volcanic rocks set in a poorly indurated matrix of red and grayish-green arkosic sand. The volcanic clasts form as much as 70 percent of the conglomerate.

The Vaqueros-Sespe sandstone and conglomeratic sandstone are poorly consolidated and erode easily. They typically have a puffy or hackly appearance. They weather characteristically to form deep, fluted, irregular and ragged gullies. The weathered surface is colored a distinctive and peculiar reddish-gray, and locally is greenish.

The Vaqueros-Sespe strata appear to represent a period of transition from nonmarine to marine depositional environment. Possibly these beds accumulated along the margin of a subsiding or fluctuating basin.

Miocene Rocks

Topanga Formation

Buff and brown sandstone and conglomerate, which crop out along the southern margin of Scully Hill, are here assigned to the marine middle Miocene Topanga formation on the basis of lithologic similarity to fossiliferous Topanga strata a few miles to the west in the southern Puente-Chino Hills. Similar strata also are exposed over an area of about half a square mile in El Cerrito Hills, southeast of Corona.

In 1923, W. S. W. Kew named the Topanga formation from exposures in Topanga Canyon in the Santa Monica Mountains. English (1926, map) assigned the middle Miocene sedimentary rocks of the Santa Ana Mountains and the southern Puente-Chino Hills to the Topanga formation and mapped this formation on Scully Hill in the Santa Ana narrows area and on the western flank of the Santa Ana Mountains.

The Topanga formation on Scully Hill is mostly a buff and tawny to white, medium-grained, arkosic sandstone. It is well indurated and well bedded, and is interbedded with cobble conglomerate. This buff sandstone is blocky and cliff-forming, and at Scully Hill has a maximum thickness of about 800 feet. The Topanga formation conformably overlies Vaqueros-Sespe beds and is apparently unconformably overlain by La Vida (Lower Puente formation) siltstone. No fossils were found.

In El Cerrito Hills, which lie southeast of Corona west of Temescal Canyon and north of Bedford Wash, buff and brown siltstone and shale, diatomaceous in a few places, with subordinate sandstone and conglomerate crop out (fig. 25). These outcrops, which form a rectangular patch about 1 mile long and half a mile wide, are assigned to the Topanga formation on the basis of lithologic and faunal evidence. Indistinct bedding and poor exposures hinder the accurate measurement of thickness, but the actual thickness probably lies within the range of 750 to 1,000 feet. Incomplete records from a wildcat well, drilled years ago southwest of State Highway 71, suggest that from 800 to 980 feet of Topanga beds were penetrated. The lower part of this thickness, however, may have been Vaqueros-Sespe strata. In El Cerrito Hills the Topanga formation apparently rests unconformably on Silverado sandstone. Here the Vaqueros and Sespe formations, undifferentiated, may be either overlapped by the Topanga formation or were removed by pre-Topanga erosion.

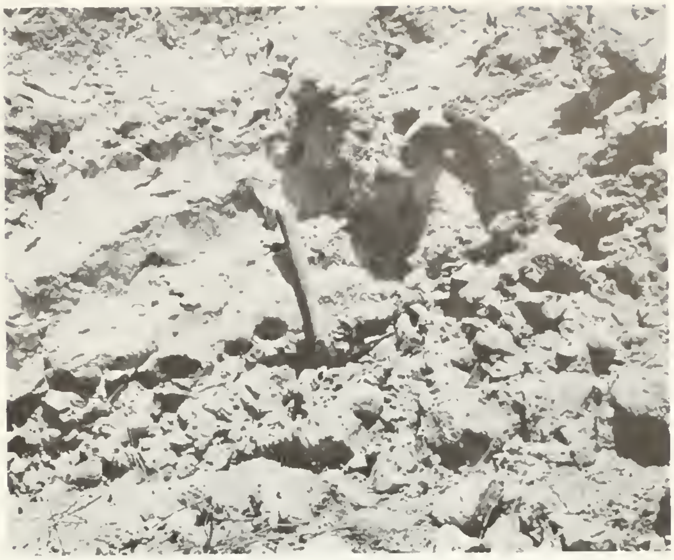

FIGURE 25. Interbedded sandy cobble conglomerate and conglomeratic sandstone of the Topanga formation. Exposed in stream bank at the east edge of El Cerrito Hills.

Paleontology. Fragmentary and poorly preserved megafossils were collected from a number of places southwest of State Highway 71 along the Metropolitan Water District pipe line, but could be dated only as Miocene. These are apparently shallow-water forms.

Microfossils were collected from localities 23, 27 and 30 (fig. 30). An excellent fauna was provided by locality 30, collected from a siltstone well exposed in a Metropolitan Water District pipeline construction ditch 20 feet deep. This fauna consists of 7 genera represented by 12 species. The collection was kindly identified by Patsy B. Smith who reports the most abundant elements represent the Luisian (middle Miocene) stage of Kleinpell (1938, p. 121-131). Two rare forms are referred by her to the lower part of Kleinpell's Mohnian (upper Miocene) stage. She accordingly called the fauna uppermost Luisian (written communication, Patsy B. Smith, October 1956). Therefore these sediments are referred to the upper middle Miocene and assigned to the Topanga formation.

Puente Formation

Marine sedimentary rocks here assigned to the Puente formation of late Miocene age crop out in the Corona South quadrangle in scattered patches along the northeastern flank of the Santa Ana Mountains southeast of Corona, and in a single band west of Wardlow Wash in the northwest corner of the quadrangle. In the Santa Ana narrows area similar strata have been assigned to the Puente formation. These strata are exposed in a narrow band south of State Highway 18 near Prado Dam and extend eastward to Wardlow Wash, and as two bands, one along the southern and the other along the northern margin of the easternmost Puente-Chino Hills. The assignment to the Puente formation of the above mentioned disconnected upper Miocene sedimentary rock outcrops along the northeastern flank of the Santa Ana Mountains in the Corona South quadrangle and in the Santa Ana narrows map area south of State Highway 18, is well supported by faunal evidence (fig. 30) discussed later in this report.

G. H. Eldridge and R. Arnold named the Puente formation in 1907 from exposures in the Puente Hills a few miles northwest of the Santa Ana narrows area. They included in this formation the lower Puente shale member, the Puente sandstone member, and the upper Puente shale member. The Puente formation commonly has been divided into three main members: lower member of shale and sandstone, middle member of sandstone, and upper member of shale, conglomerate and sandstone. English (1926, p. 33-38) used this designation as did Woodford and others (1944), who assigned the Puente to the upper Miocene. Recently Schoellhamer and others (1954) have divided the Puente formation into four members in the southeastern Puente-Chino Hills and in the Santa Ana Mountains. From bottom to top these are: (1) La Vida member, consisting mainly of laminated siltstone with thin interbedded sandstone; (2) the Soquel member, consisting of sandstone with interbedded siltstone and local conglomerate beds; (3) the Yorba member, consisting of thin-bedded siltstone and local beds of sandstone and conglomerate; and (4) the Sycamore Canyon member, consisting of interbedded conglomerate, sandstone and siltstone. The writer uses the names proposed by Schoellhamer and others (1954) because they correspond more closely to the actual stratigraphic units of the Puente formation in this area than do the older and more general names.

La Vida Member

La Vida member is exposed as a narrow belt across Scully Hill. This belt, consisting mainly of siltstone, is about 1,000 feet wide at the eastern margin of the hill and narrows to 200 feet or less to the west where it extends under terrace deposits. The maximum true thickness is about 800 feet. The siltstone weathers to form characteristic rounded, soft slopes and a grayish-brown clayey soil.

La Vida member is mostly a fine-grained laminated siltsone but contains intercalated fine-grained shale beds and minor interbedded buff, medium-grained sandstone. The lower Puente formation in nearby areas commonly includes much platy, siliceous, fine-grained shale but this lithology was not seen on Scully Hill. On fresh exposures La Vida siltstone is gray to pale brown, but most outcrops have weathered to a darker brown or pinkish color. La Vida member unconformably overlies the Topanga sandstone as indicated by a small discordance of dips. On Scully Hill, La Vida member is in fault contact with the overlying Soquel member; but elsewhere in the Puente Hills the contact between La Vida and Soquel members is gradational and at one place a local unconformity exists between the two members (Schoellhamer and others, 1954). La Vida member is seemingly marine, but no identifiable fossils were found.

Soquel Member

Tawny, buff to white and gray sandstone crops out along the north side of the Santa Ana River from east of Yorba Canyon to the western margin of Scully Hill. The outcrop ranges in width from about 700 feet on the east to nearly 1,500 feet on the west. The calculation of thickness is made difficult by irregular attitudes and by slumping but the maximum is probably about 700 feet. This sandstone is here assigned to the Soquel member of the Puente formation because of its stratigraphic position and lithologic similarity to the Soquel member described by Schoellhamer and others (1954). The Soquel member is in fault contact with the underlying La Vida member. The upper contact between the Soquel and Yorba members is gradational.

The sandstone contains intercalated stringers or lenses of cobble conglomerate. It is rather poorly bedded, is generally soft, and medium-grained. It is composed mostly of poorly sorted subangular quartz and feldspar grains. The member locally contains beds of buff and gray siltstone. The Soquel member forms a more rugged and broken topography than either the underlying or overlying siltstones.

Yorba Member

Siltstone similar lithologically to La Vida member, but with the stratigraphic position to assign it to the Yorba member, crops out just east of Yorba Canyon and extends westward across Scully Hill. The outcrop width is about 400 feet east of Yorba Canyon and some 1,500 feet in the western part of the mapped area; evidently the Yorba member continues to thicken to the west. The maximum true thickness within the mapped area is probably 1,200 feet.

This siltstone in general forms a rounded, gentle topography. It is pinkish to gray on a fresh surface and weathers to a brownish-gray soft soil. The Yorba member ranges from a massive to fissile, thin-bedded, buff or gray siltstone and contains interbedded massive, fine-grained, buff sandstone.

The Yorba member overlies the Soquel member somewhat gradationally but the contact is located rather closely by lithologic and topographic evidence. This is demonstrated by a marked contrast between the rough topography developed on the Soquel sandstone and the smooth rounded slopes developed on the Yorba siltstone. Schoellhamer and others (1954) report that the contact between the Yorba member and the underlying Soquel member is gradational throughout the Puente Hills.

Sycamore Canyon Member

Sandstone, conglomerate and siltstone crop out along the north side of Santa Ana Canyon west of Prado Dam, extend westward to Yorba Canyon and continue west of the mapped area. These rocks are assigned to the Sycamore Canyon member on the basis of lithology and stratigraphic position. The width of outcrop ranges from about 700 feet near Prado Dam to 4,500 feet at the western end of the mapped area and continues to widen to the west. Similar strata crop out on the southwest side of the Chino fault. The true thickness of the Sycamore Canyon member is not easily calculated but probably is about 2,700 feet maximum near Yorba Canyon and much greater to the west.

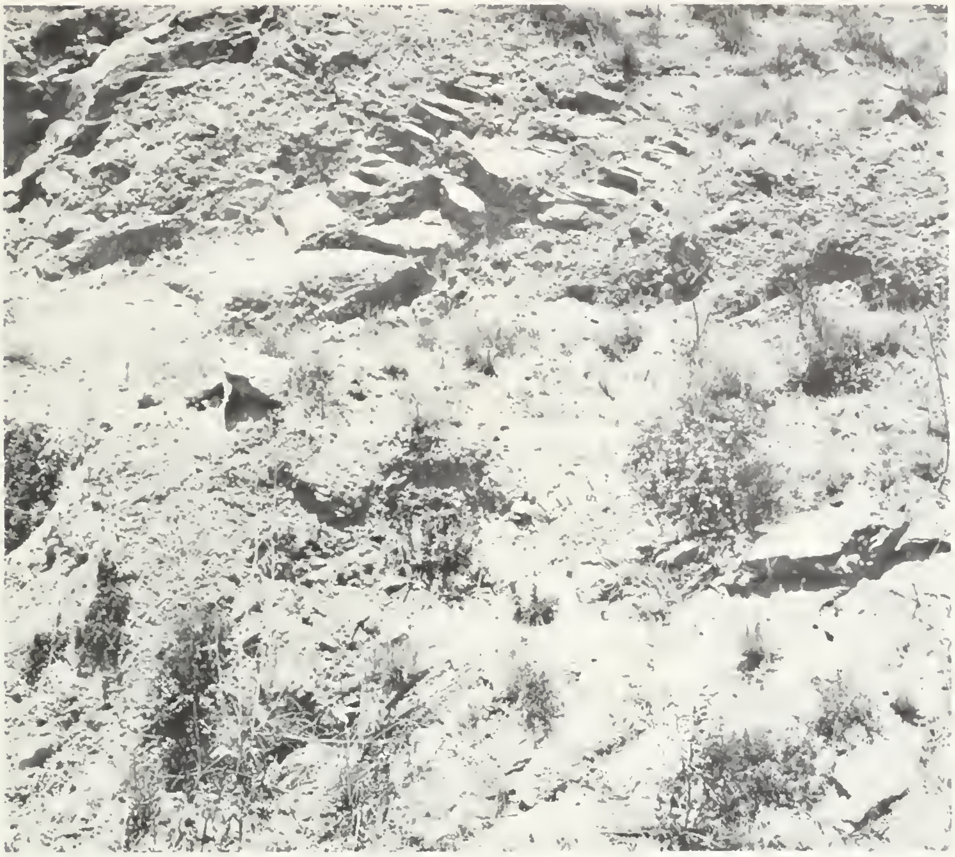

FIGURE 26. Interbedded, tawny, coarse-grained sandstone and cobble conglomerate, Sycamore Canyon member of the Puente formation. Exposed in stream cut, northeast side of Yorba Canyon, southeastern Puente-Chino Hills. Observer faces northeast.

The Sycamore Canyon member in this area is composed chiefly of buff or tawny to gray and white medium- to coarse-grained, massive to well-bedded sandstone, abundantly interbedded with cobble conglomerate that contains granitic and volcanic clasts (fig. 26). Buff or tawny siltstone is also included. The sandstone is poorly sorted and is mostly composed of subangular grains of quartz and feldspar. In general the sandstone is similar to that of the Soquel member, except for more extensive conglomerate. In many places the sandstone stands out to form bold cliff faces and a rugged topography. Buff or tawny siltstone (figs. 27, 28) is locally

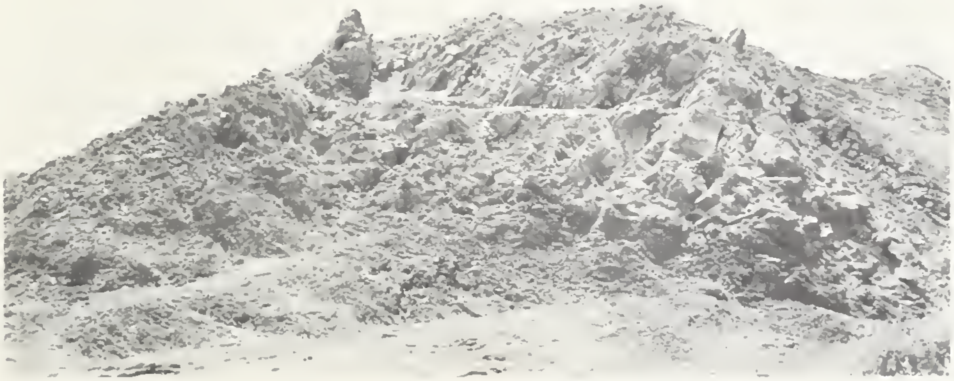

FIGURE 27. Siltsone, shale and limy siltstone (light area, center), Sycamore Canyon member of the Puente formation. Beds dip about 40° away from observer. Exposed along north side of Santa Ana River at southeastern tip of Puente-Chino Hills, half a mile southwest of Prado Dam. Observer faces north.

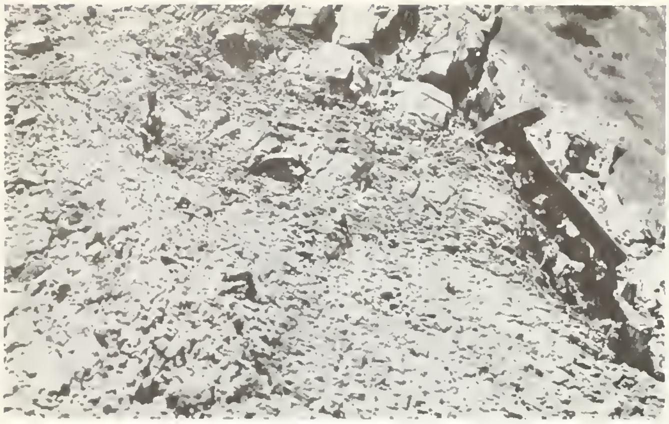

FIGURE 28. Detail of interbedded buff siltstone and gray limy siltstone (marked by hammer), Sycamore Canyon member of the Puente formation. Beds dip about 40° away from observer. Exposed along north side of Santa Ana River at southeastern tip of Puente-Chino Hills. Observer faces north.

interbedded with the sandstone and conglomerate and is minor near Prado Dam but thickens greatly to the west along Yorba Canyon. In places it contains limy siltstone beds.

The Sycamore Canyon member conformably overlies the Yorba member in a gradational contact. Although this contact is not sharp in the southeastern tip of the Puente-Chino Hills it is drawn along the base of the first massive coarse-grained sandstone and conglomerate bed above Yorba siltstone. Sandstone, siltstone, and conglomerate of probable Pliocene age gradationally overlie the Sycamore Canyon member.

Puente Formation, Undifferentiated

Sandstone, conglomerate, thin-bedded siltstone, and laminated diatomaceous siltstone crop out along the south bank of the Santa Ana River south of Prado Dam in the Santa Ana narrows map area. These rocks form a band, as much as 1,000 feet in width, extending east from Santa Ana River to Wardlow Wash in the northwest corner of the Corona South quadrangle. Patches of these strata also crop out at several localities southeast of Corona from where they extend as far east as Brown Canyon at the east central margin of the Corona South quadrangle. These rocks, shown as undifferentiated Puente formation, probably have a maximum thickness of 1,000 feet south of Prado Dam although true thickness is difficult to establish because of irregular attitudes and slumping. Southeast of Corona the Puente formation may be much thinner.

Upper Miocene strata along the northeastern margin of the Santa Ana Mountains are designated as Puente formation, undifferentiated, because the stratigraphic relations of the scattered outcrops, to one another, are not clear. Possibly the same sequence of Puente formation units that was mapped in the southeastern Puente-Chino Hills extends across the Santa Ana River narrows and is present in the Corona region. The various members of the Puente formation in the Puente-Chino Hills appear to thin to the east and thus strata of each member could exist east of the Santa Ana River and be represented in the narrow band of Puente beds which is exposed south, southeast of Prado Dam. South of Prado Dam the Puente formation includes a lower unit of shaly siltstone, a middle unit of sandstone and conglomerate and an upper unit of shaly siltstone. These units may be equivalent to the members mapped west of the Santa Ana River, but in the absence of positive evidence these rocks probably are best designated as Puente formation, undifferentiated.

Along the south side of the Santa Ana River buff to brown medium-grained sandstone and siltstone of the Puente formation, undifferentiated, crop out as far east as Wardlow Wash. These are interbedded with conglomerate and upward the formation is a buff and pinkish to gray shale and thin-bedded siltstone with diatomaceous siltstone lenses. Thin, hard limy beds, locally carrying an abundant microfauna, are intercalated with the shale and siltstone (fig. 29). These Puente strata are exposed in a narrow band which averages about 500 feet in width, but is as much as 800 feet wide, and is about 1½ miles long. The maximum true thickness is about 750 feet.

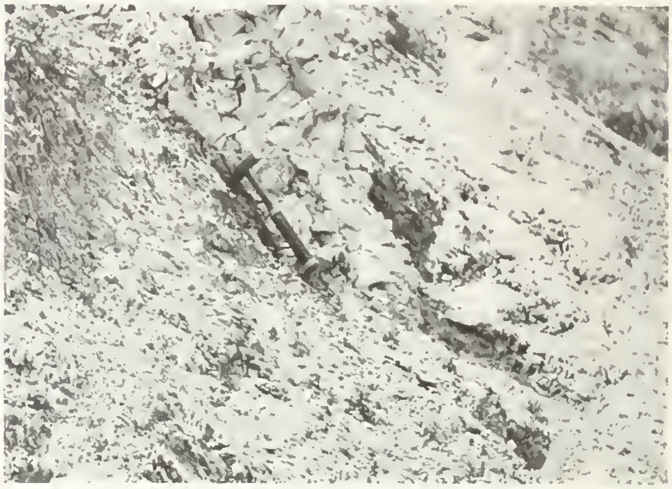

FIGURE 29. Siltstone and shale of the Puente formation, undifferentiated with intercalated limy bed (above hammer). Exposure in cut on State Highway 18 east of Fresno Canyon. Note similarity to Sycamore Canyon member of the Puente formation shown in fig. 28. Observer faces south.

Here these Puente beds rest, apparently with fault contact, on Vaqueros-Sespe beds. The Topanga formation apparently is cut out. Along part of the contact, midway between Wardlow Wash and Santa Ana River, the lowermost exposed unit of the Puente formation is a cobble conglomerate and is overlain by rather blocky, massive, buff and gray sandstone which grades upward into platy siltstone and shale. Evidently this is the typical sequence of the Puente formation in this area. Here the lower siltstone unit, which occurs below the sandstone and conglomerate unit at a locality near the east side of the Santa Ana River, apparently has been cut out by faulting. Pliocene (?) strata apparently conformably overlie the Puente formation.

East of Corona along State Highway 71, near the northwest end of the Elsinore trough, patches of Puente strata crop out above the alluvium-filled valley. The rocks are white to greenish-gray thin-bedded diatomaceous siltstone, buff to gray siltstone and shale, and brown or buff, medium-grained sandstone with local, rounded cobble, conglomerate lenses. Here the Puente formation is probably thin. The maximum provable thickness measured from outcrops is about 300 feet, but projections in cross sections indicate a possible thickness of about 1000 feet. It is at least locally conformable upon the Topanga formation along the west margin of El Cerrito Hills, whereas to the north, near Compton Siding, it rests directly on basement rocks. To the south, along the west side of Bedford Canyon, diatomaceous siltstone and shale of the Puente formation are in fault contact with Paleocene Silverado strata below and Pliocene (?) rocks above. In some places the Pliocene (?) rocks appear to overlie Puente beds conformably. East of Bedford Canyon Puente siltstone and shale rest with fault contact on Vaqueros-Sespe beds. Several fault slivers of Puente siltstone and shale crop out along Brown Canyon.

Paleontology. The Miocene age of the beds that are referred to the undifferentiated Puente formation is well established by the microfauna (fig. 30). Patsy B. Smith has examined the collections and reports that localities 17, 24, and 25 can be referred to the upper Mohnian stage of Kleinpell (1938, p. 121-131); localities 18, 21 and 32 are probably upper Mohnian stage and localities 19 and 26 apparently represent Kleinpell's Luisian stage (oral communication, Patsy B. Smith, 1953). Mohnian is considered to mean upper Miocene, and Luisian indicates middle Miocene. However, Luisian foraminifera are no barrier in assigning these sedimentary rocks to the Puente formation and the Luisian stage localities furnished too few forms to be conclusive.

Genus and species	Fossil localities (shown on pl. 1)											
Foraminifera	17	18	19	21	22	23	24	25	26	30	32**	27
Bolivina cf. B. decurtata Cushman											x	
Bolivina floridana Cushman										c		
Bolivina hughesi Cushman	x						x	x				
Bolivina tumida Cushman										a		
Bolivina cf. B. vaughani Natland											x	
Bolivina woodringi Kleinpell	x	x										
Bolivina cf. B. woodringi Kleinpell											x	
Bolivina sp.			x	x								
Bulimina montereyana Kleinpell	x	x			x	x		x		a		
Bulimina ovula d'Orbigny			x									
Bulimina cf. B. uvigerinaformis Cushman & Kleinpell										r		
Buliminella curta Cushman	x	x							x			
Buliminella subfusiformis Cushman		x										
Epistominella relizensis (Kleinpell)										a		
Epistominella gyroidinaformis (Cushman & Goudkoff)										c		
Gyroidina soldanii var. rotundimargo R. E. & K. C. Stewart		x									x	
Hemicristellaria beali (Cushman)			x									
Nonion costiferum (Cushman)										a		
Nonion pizarrensis W. Berry										c		
Uvigerina carmelosensis Cushman & Kleinpell										r		
Uvigerina subperegrina Cushman & Kleinpell											x	
Valvulineria araucana d'Orbigny		x					x					
Valvulineria californica Cushman			x						x			
Valvulineria californica var. obesa Cushman										f		
Valvulineria cf. V. grandis Cushman & Galliher										c		
Valvulineria sp.				x								
Virgulina californiensis Cushman		x				x		x		a		
Diatoms												
Coscinodiscus sp.												x

* Identified by Patsy B. Smith
** Locality 32 identified by Richard L. Pierce

a—abundant
c—common
f—few
r—rare

FIGURE 30. Miocene faunal list*.

The Corona area apparently marks the eastern margin of a shallow, fluctuating basin of Tertiary deposition. In this region middle and late Miocene microfaunas may have overlapped and as a result of local depositional environments in segregated areas, beds containing these microfaunas may appear to interfinger so that it is not always possible to separate these strata into middle and upper Miocene units on the basis of scattered occurrences of microfauna. Under these conditions the Miocene microfaunal stages of Kleinpell may not strictly apply.

Pliocene (?) Rocks

Pliocene, Undifferentiated

White sandstone with interbedded conglomerate and buff or gray siltstone, crop out in the southeastern tip of the Puente-Chino Hills and evidently extend eastward across the Santa Ana River to Wardlow Wash. Southeast of Corona in the vicinity of Bedford and Joseph Canyons, similar strata crop out. These rocks, at each locality, are assigned a probable Pliocene age on the basis of lithologic, stratigraphic, and faunal evidence. Most, if not all, of the probable Pliocene rocks in the Puente-Chino Hills may belong to the Sycamore Canyon member of the Puente formation. However, in the field the white sandstone with interbedded siltstone and conglomerate comprise a mappable unit and accordingly are delineated on the geologic map.

English (1926, p. 38) recognized that part of the strata mapped in the Puente Hills as upper Puente formation might possibly be Pliocene. Later workers provisionally established the Pliocene age on a faunal basis and Woodford and others (1944) show Pliocene strata in the southeastern Puente-Chino Hills. The faunal evidence is not conclusive, however.

North of the Santa Ana River, in the vicinity of Prado Dam, Pliocene (?) strata occupy the center of the Arena Blanca syncline and crop out over an area about 7,500± feet wide. They have a maximum stratigraphic thickness of 3,000± feet. The Pliocene (?) beds are composed of coarse, white, arkosic sandstone with interbedded conglomerate and alternate with beds of black or grayish-brown to buff fine-grained sandstone, siltstone and shale (figs. 31-34). The conglomerate clasts are mostly well-rounded pebbles and cobbles of granitic rocks, but with some quartzites and minor amounts of volcanic rock, set in a generally weakly cemented arkosic sandstone matrix. The white Pliocene (?) sandstone weathers easily and forms an irregular topography with steep, jagged, and fluted ridges (fig. 31).

The Pliocene (?) strata in the southeastern tip of the Puente-Chino Hills gradationally overlie the Sycamore Canyon member of the Puente formation along both limbs of the syncline. This gradational contact is inferred as no continuous marker horizon was found. Moreover, although Pliocene foraminifera have been reported by Roscoe and Katherine Stewart (1930) and also by Woodford and others (1944), these scattered fossil localities do not closely determine the contact.

North of the Chino fault, are exposures of a unit composed of buff to gray and pinkish shale and siltstone with minor amounts of interbedded sandstone and conglomerate. Pliocene foraminifera are reported by Price (1953) to have been found in this unit farther northwest.

White sandstone with interbedded conglomerate and buff to gray siltstone and shale, of probable Pliocene age, are exposed southeast of the Santa Ana River around the Prado Dam spillway and continue eastward to Wardlow Wash. Lithologically they appear to be identical with the Pliocene (?) strata west of Prado Dam except for a reddish brown, micaceous, "dirty" arkosic, platy sandstone and siltstone exposed in the railroad cut north of Wardlow Wash. These Pliocene (?) rocks apparently grade downward into Puente siltstone and shale. An extensive development of terrace deposits, resting in sharp angular unconformity, covers much of the Pliocene (?) rocks east of the Santa Ana River so that they are only exposed in road cuts and ravines.

A Pliocene age is indicated by microfossils from locality 20, just west of Wardlow Wash. Patsy B. Smith examined material from this locality and reported the presence of *Rotalia* cf. *beccarii* (Linné) and *Bolivina seminuda* Cushman (oral communication, May 1953). These two forms indicate a probable upper Repetto age (lower Pliocene) but are not sufficiently diagnostic to rule out a possible upper Pliocene age, and Natland and Rothwell (1954, pp. 34, 40) include *Rotalia beccarii* with Pleistocene guide fossils in the Los Angeles Basin. They are shallow water or lagoonal forms indicating probable deposition along the margins of a basin, perhaps in a lacustrine environment. This depositional environment is evidenced by the beds at locality 20 as well as by the fossils, as the collection was made from a small outcrop of white to gray, somewhat thin-bedded, claystone which has the characteristic appearance of lake bed material. A second collection, made several years later from the same beds in the vicinity of locality 20, was examined by Richard L. Pierce who reports an abundance of *Eponides* sp. which is not diagnostic.

Southeast of Corona, in the vicinity of Bedford and Joseph Canyons, patchy outcrops of white, coarse, arkosic sandstone with conglomerate lenses and a few thin, gray siltstone layers (fig. 35) are here assigned to the Pliocene. The components of the sandstone are mostly medium- to coarse-grained, subangular feldspar and quartz fragments. The sandstone is poorly sorted and contains pebbles and small cobbles of granitic, metamorphic and volcanic rock. It locally contains cobble-sized clasts of grayish-green siltstone which may be reworked from the Puente strata. The sandstone is poorly bedded and only weakly indurated. It overlies Puente siltstone and shale, in a few places apparently conformably, but in most exposures is faulted against the Puente beds.

A meager megafauna from locality 14, on the northwest side of Bedford Canyon, indicates a Pliocene age. J. G. Vedder has examined these fossils and reports: ". . . the material is too poor to give names but appears to be Pliocene. One fragment is *Cantharus* sp. and indicates Pliocene" (oral communication, 1953). The beds at locality 14 are composed of reddish-brown, micaceous, "dirty" arkosic, platy sandstone and siltstone. They appear to be lithologically similar to beds, already described, exposed in a railroad cut west of Corona and north of Wardlow Wash. Locality 28, on the northwest side of Bedford Canyon, yielded only ostracods.

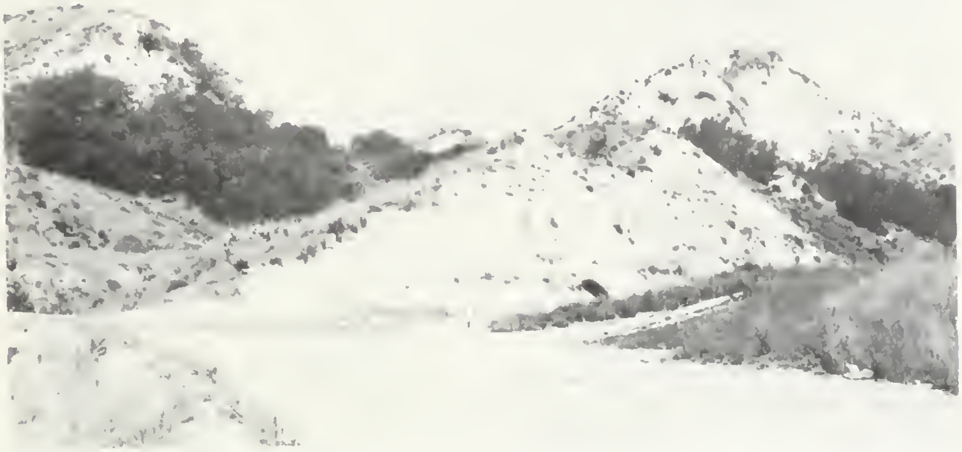

FIGURE 31. Moderately south-dipping white sandstone and conglomerate of Pliocene (?) age in the north limb of the Arena Blanca syncline, just beyond axis. Note steep and ragged weathered surfaces. Exposure in cut on State Highway 71, northwest of Prado Dam. Observer faces northwest.

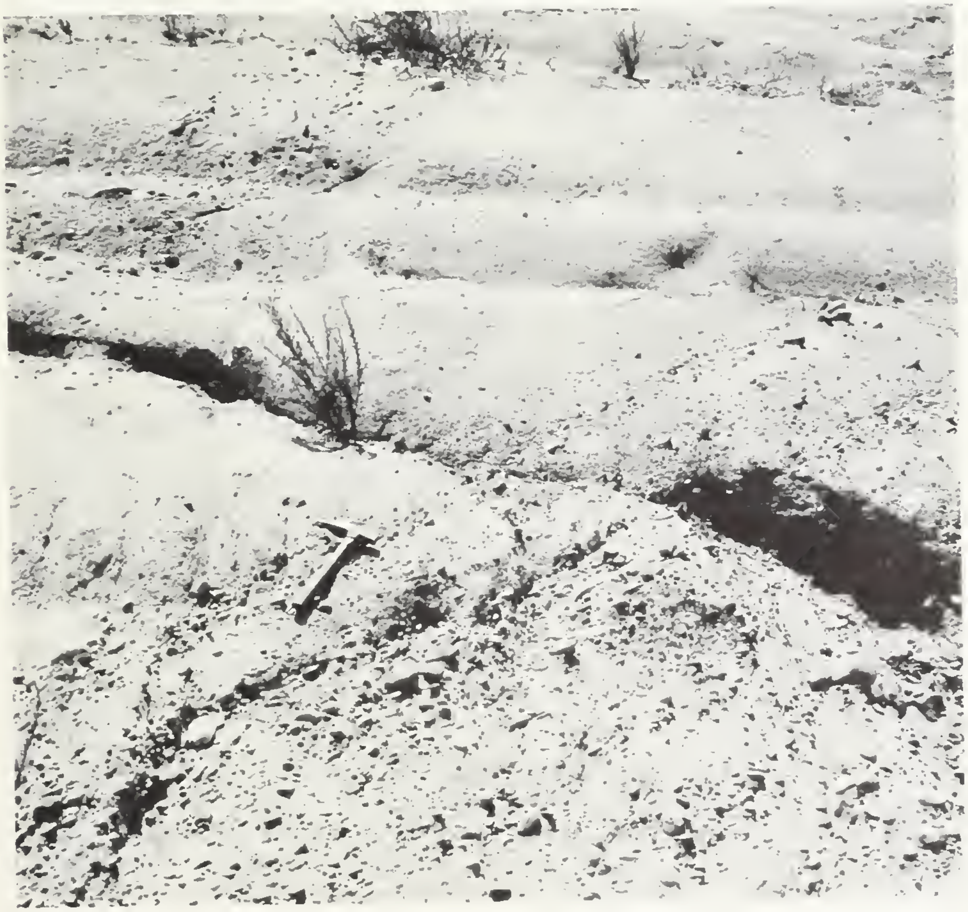

FIGURE 32. Close-up view of fig. 31 showing detail of white sandstone and conglomerate of Pliocene (?) age. Observer faces northwest.

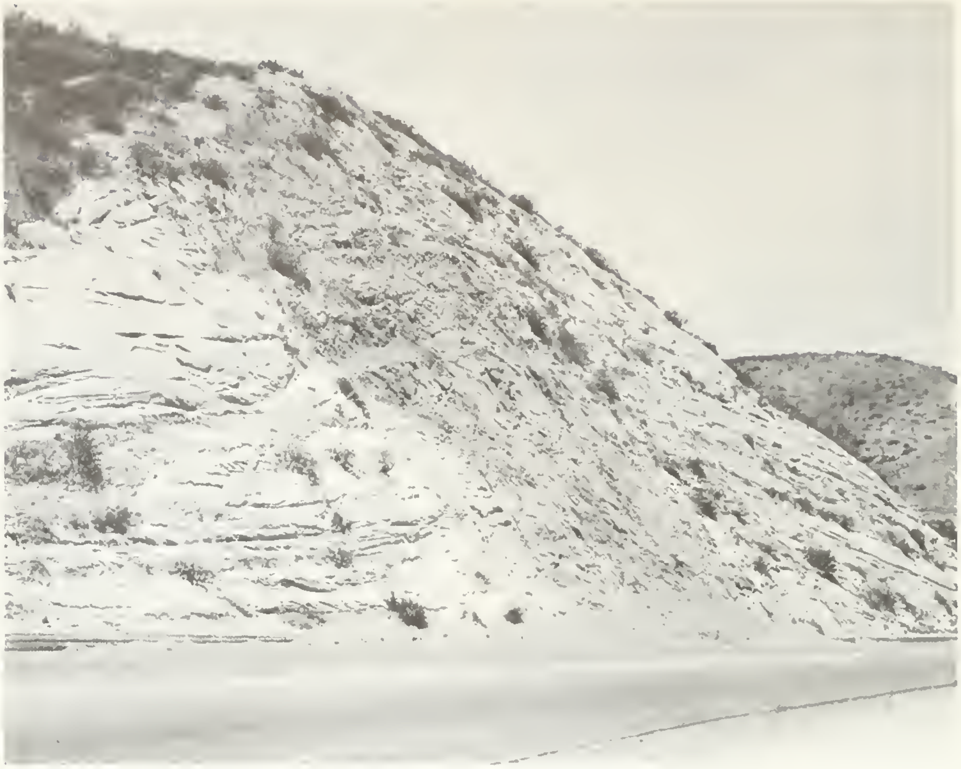

FIGURE 33. Steeply north-dipping interbedded white sandstone and dark gray siltstone of Pliocene (?) age. South limb of Arena Blanca syncline exposed in cut on State Highway 71, southwest of Prado Dam. Observer faces west.

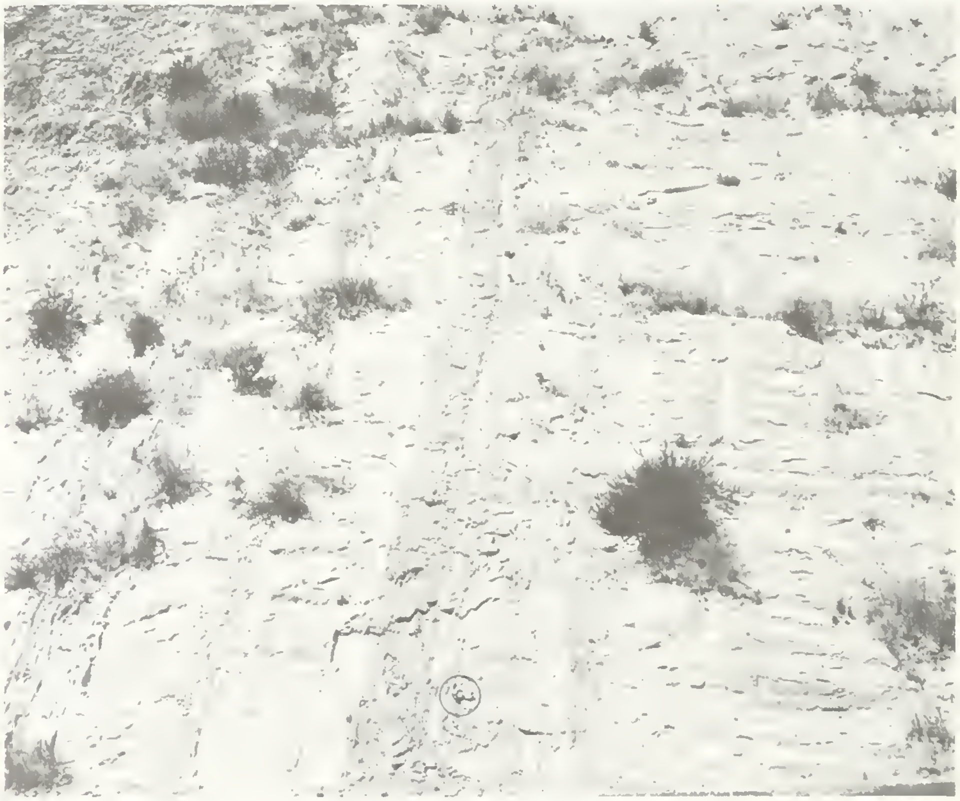

FIGURE 34. Detail of the interbedded white sandstone and dark gray siltstone of Pliocene (?) age shown in fig. 33. Light meter (circle) gives scale. Observer faces west.

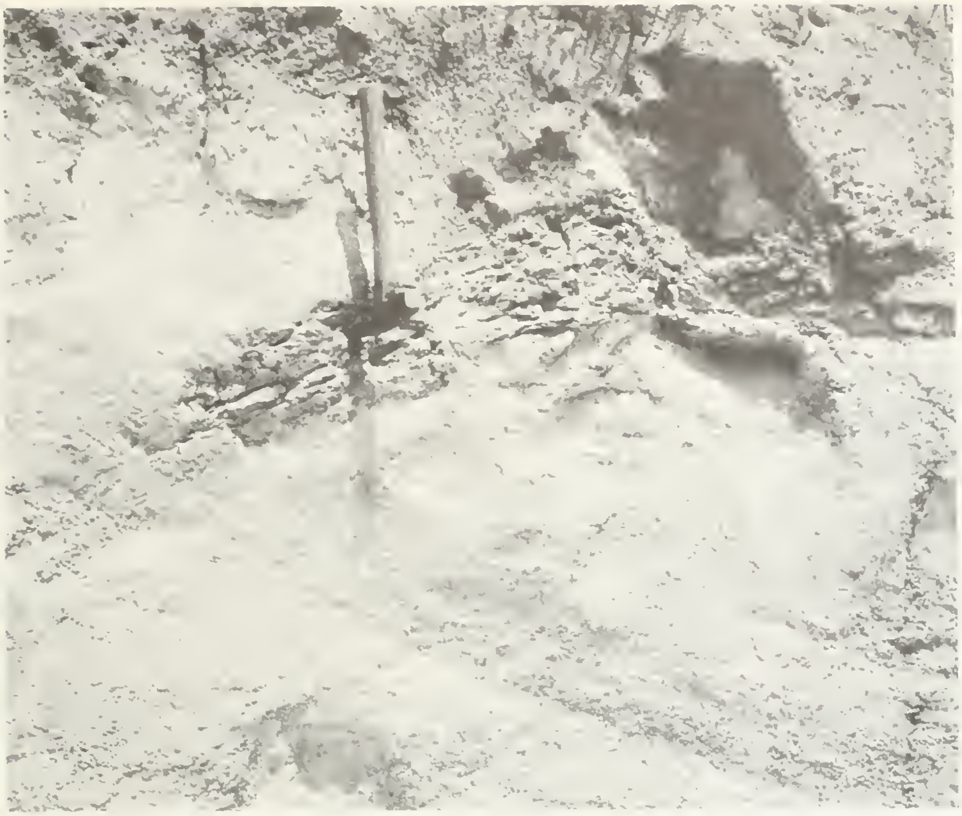

FIGURE 35. Poorly consolidated, massive, white arkosic sandstone of Pliocene (?) age exposed at the Jones sand deposit, east of Joseph Canyon. Note thin, gray siltstone layer (marked by hammer). Observer faces west.

Quaternary System

Pleistocene (?)—Recent Rocks

Terrace Deposits

Extensive terrace deposits occur along the northeastern flank of the Santa Ana Mountains from the eastern boundary of the mapped area to the Santa Ana River (fig. 36) and along the southern margin of Scully Hill west of the river. The terrace deposits are unconsolidated gravels made up of angular to subrounded fragments of volcanic, granitic, metamorphic and sedimentary rocks set in a reddish to yellow-brown or buff weakly indurated "dirty" sandy matrix (fig. 37). The typical color is reddish-brown. Most of the clasts are of cobble size but some are boulders. On the flat terrace surfaces large residual boulders as much as three feet in diameter are occasionally encountered. In general the components correspond closely to the sedimentary and basement-complex types found nearby in the Santa Ana Mountains, indicating local derivation. The lower terrace deposits mapped between Bedford and Brown Canyons, however, appear to have been carried down Temescal Creek, rather than from the Santa Ana Mountains.

Some of the terrace deposits are much dissected, but in general they have nearly flat surfaces. In thickness they range from less than 1 foot to 50 feet or more and in places may approach 150 feet. The terrace deposits truncate the older sedimentary rocks with sharp angular unconformities.

No clear evidence for dating the terrace deposits was observed. They have been faulted, truncate Pliocene (?) sedimentary rocks, and are apparently overridden by probable late Pleistocene or Recent landslide material along the southern margin of Scully Hill. From this evidence the terrace deposits are believed to be, at least in part, of Pleistocene age. Some are probably Recent.

Older Alluvium

The town of Corona and the citrus acreage to the south are developed on a surface of older alluvium. This area is termed the Corona compound alluvial fan.

The older alluvium is composed of material similar to that of the terrace deposits (fig. 38). However, the clasts are in general smaller in the older alluvium, the color is characteristically buff to dark brown, rather than the typical reddish-brown of the terrace deposits, and a thicker soil has developed on the older alluvium.

The observed thickness of the older alluvium ranges from only a few feet to a probable maximum of 100 feet, the thickest occurrence being exposed along Bedford Canyon. Eighty feet of older alluvium were penetrated in a drill hole south of the Liston Brick Company plant on the east margin of lower Bedford Wash. No conclusive evidence for dating the older alluvium was found. The deposits are, however, probably mostly of Recent age, as they commonly are but little dissected and generally are undeformed, although some may be as old as late Pleistocene.

At a few places the terrace deposits and older alluvium are difficult to distinguish. This is particularly true south of Corona where flat-topped ridges, covered with fanglomerate deposits, slope gradually northward into

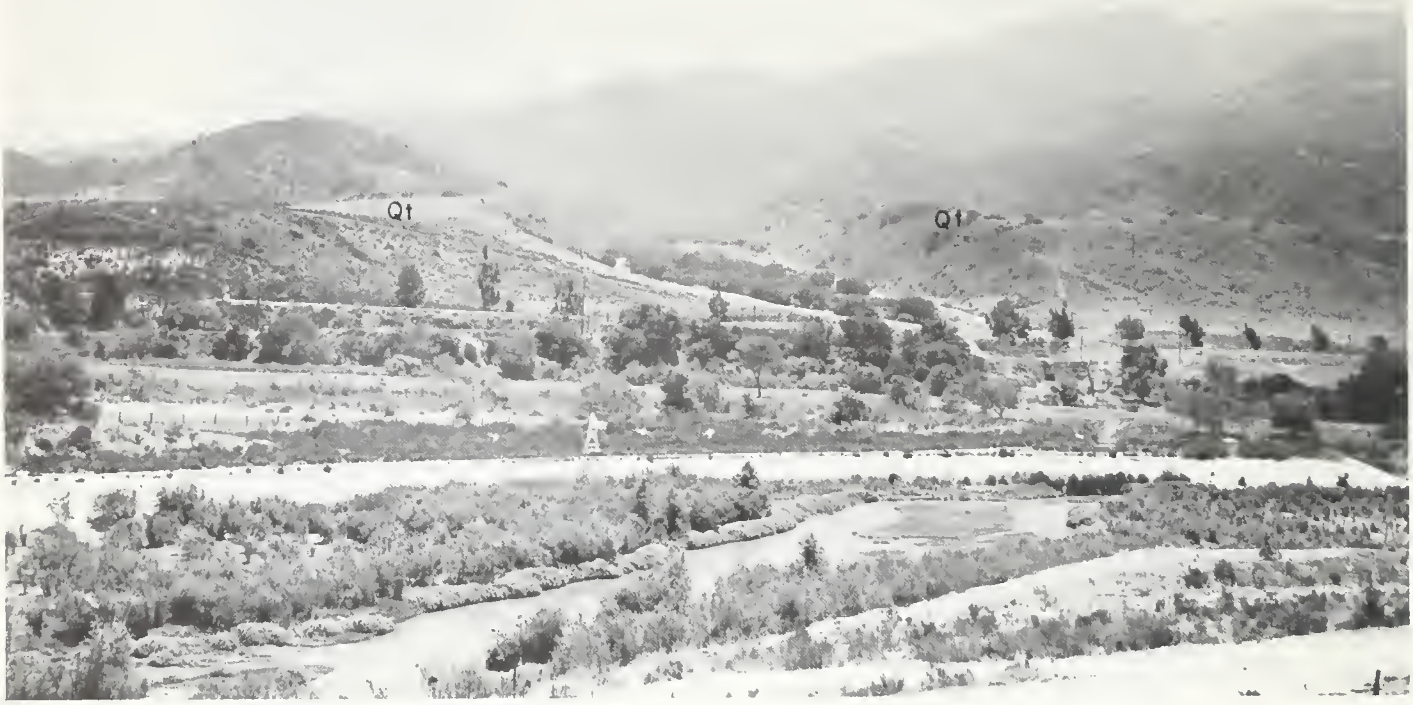

Figure 36. View south across Santa Ana River toward Fresno Canyon (center) showing gently north-sloping terrace deposits (Qt) along both sides of the canyon. Tertiary and Cretaceous sedimentary rocks (middle distance) rise sharply behind terraces. Central mass of the Santa Ana Mountains (background) consists of Santiago Peak volcanics.

the Santa Ana River valley. The areas at lower elevations appear to be more closely related to the Corona compound fan, and are mapped as older alluvium. Those at higher elevations, closer to the mountains, and in most places distinctly separated from the Corona compound fan, are mapped as terrace deposits.

Recent Rocks

Alluvium

The lower reaches of the creek beds are filled with a mixture of unconsolidated sand, rounded pebbles and cobbles and a few boulders. Upstream many large angular to sub-angular boulders are encountered. The components of all of the alluvium, except that in Temescal Creek, are locally derived volcanic, granitic, sedimentary and metamorphic rocks. The tributaries of Temescal Creek drain a large area in the Santa Ana Mountains and Perris Block underlain by a host of different volcanic, granitic, and metamorphic rock types and thus the creek bed has much material foreign to the Corona area, and of distant origin.

The Recent alluvium ranges from only a thin veneer in the minor creeks to a cover with a probable maximum thickness of about 100 feet in the Santa Ana River; ninety-four feet are reported at Prado Dam (W. L. Burnham, oral communication, 1953). An exploratory drill hole in lower Bedford Wash is believed to have penetrated over 100 feet of alluvium before entering Paleocene sedimentary rocks.

The major canyons and creek beds of the Corona area have along their borders a considerable deposit of alluvial material which apparently is not being currently transported by water. This alluvial material may, however, be subject to transportation at widely spaced irregular intervals as a result of flood conditions. These gravels have been included with the alluvium on the geologic map as they clearly are not part of the Corona compound fan.

STRUCTURAL GEOLOGY

General Features

The Corona area (figs. 39-41) lies just within the eastern margin of the Los Angeles Basin which, beginning in middle Tertiary time, has received great thicknesses of sedimentary rocks. During much of middle and late Tertiary time an embayment extended southeastward from the Los Angeles Basin into the area now occupied by the Corona-Elsinore trough. The middle and late Tertiary strata that are now exposed in the Corona area are, in general, the near-shore facies of formations that are widely recognized elsewhere in the basin. These sedimentary rocks, as well as the formations of earlier Tertiary

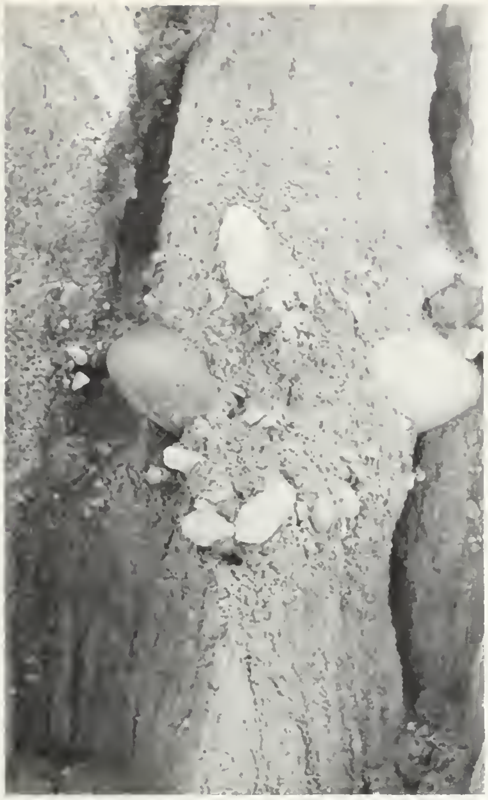

Figure 37. Terrace deposits exposed in roadcut near the railroad one mile west of Fresno Canyon. Observer faces east.

and Mesozoic age, have been both complexly folded and faulted in late Cenozoic time.

The dominant fold in the Corona area (fig. 48) is the Santa Ana Mountains anticline, the apparent crest of which approximately coincides with the crest of the mountains. In the central part of the mapped area, this anticline is paralleled on the northeast by the small and shallow Arena Blanca syncline, which is well-exposed in the southeastern Puente-Chino Hills. Along the northeastern flank of the Santa Ana Mountains a group of high-angle reverse faults and vertical faults, offset in places by cross faults, lie generally parallel to the northwesterly trend of the Santa Ana Mountains and disturb the southwest limb of the Arena Blanca syncline. Overturned strata are common.

Figure 38. Typical exposure of older alluvium along northwest side of Bedford Canyon. Observer faces northwest.

Three major structural blocks can be distinguished in the Corona-Santa Ana narrows region (fig. 48): (1) the Santa Ana Mountains block bounded on the northeast by the Elsinore and Whittier faults; (2) the Puente-Chino Hills block bounded on the northeast by the Chino fault and on the southwest by the Elsinore and Whittier faults; and (3) the Corona-Chino valley block on the northeast side of the Chino fault.

Faults

Major Faults

Elsinore Fault

The Santa Ana Mountains have long been recognized as uplifted along a fault zone which lies along their northeastern margin and which many workers have called the "Elsinore fault zone". W. M. Davis (1927, p. 57) well described the trace of this structural feature when he wrote: " . . . the Elsinore rift, which borders the northeastern flank of the Santa Ana Mountains . . . is peculiar in being curvilinear and in exhibiting along its western side a succession of concave bights, each a few miles in length, separated by blunt salients or cusps." The fault zone, which has been traced south-southeastward from the mapped area for a distance of at least 110 miles (Larsen, 1948, pp. 119-127, pl. 1; Jahns, 1954, pp. 29-52, pl. 3) characteristically occupies a trough-like depression and contains several parallel to subparallel faults. At most places, the fault with the most prominent topographic expression has been designated as the "Elsinore fault". In the Corona South quadrangle the Elsinore fault zone occupies the Corona-Elsinore trough whereas the term "Elsinore fault" is herein applied to the most southwesterly of the major faults in the zone and the one along which the Santa Ana Mountains have risen.

In the mapped area the Elsinore fault, which is steep and sinuous and separates dissimilar rock types, can be traced northwestward across the entire mapped area from Temescal Valley to the southeast side of Santa Ana Canyon. The longest continuous segment of the Elsinore fault within the mapped area extends from the northwest corner of Temescal Valley near Brown Canyon to a point just west of Fresno Canyon. Here the fault ordinarily strikes N. 60° to 70° W. The trace of this segment, which is about 10 miles long, generally bends several hundred feet upstream in the canyons and curves out around the noses of the ridges. West of Fresno Canyon the segment terminates against a cross fault and thence an apparent northeasterly offset segment of the Elsinore fault extends nearly due westward to a point just southeast of Santa Ana Canyon where it evidently again assumes a northwesterly strike.

In the southwestern corner of the Corona South quadrangle, between Brown and Anderson Canyons along the southwest margin of Temescal Valley, the frontal fault of the Santa Ana Mountains is subparallel to and has the same sense of movement as the major segment of the Elsinore fault in the mapped area northwest of

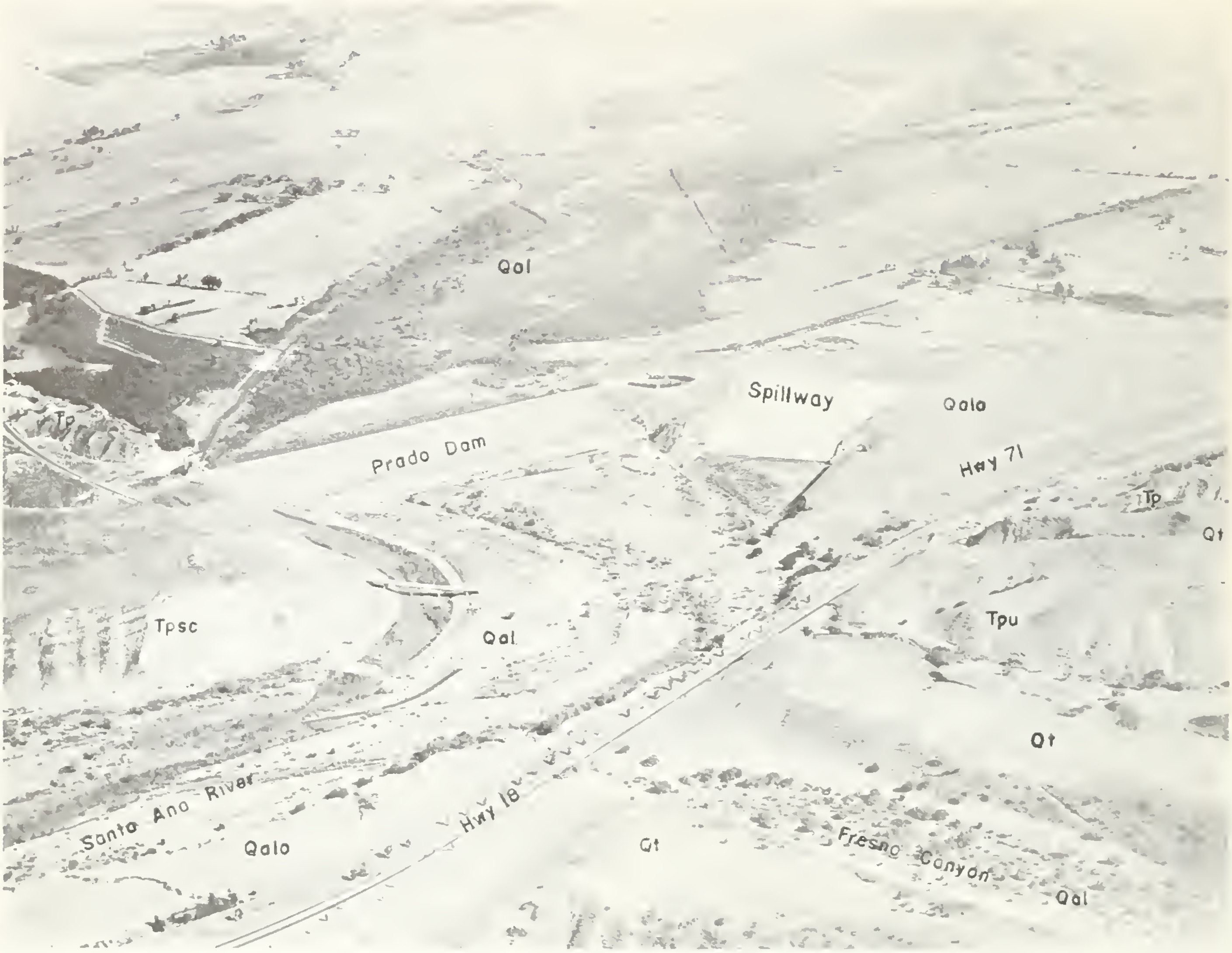

FIGURE 39. Oblique aerial view of the east end of Santa Ana Canyon at Prado Dam. The axis of the Arena Blanca syncline is at left just beyond Prado Dam. The center of the syncline is formed by Pliocene (?) sediments (Tp), and the Sycamore Canyon member of the Puente formation (Tpsc) forms the margins. The Santa Ana River course (center) is filled with Quaternary alluvium (Qal) and the river marks the geographical division between the Puente-Chino Hills (left) and the foothills of the Santa Ana Mountains (right). Older Quaternary alluvium (Qalo) in right middle distance forms the Corona compound alluvial fan. South of State Highway 18 flat-topped terrace deposits (Qt) overlie the Puente formation undifferentiated (Tpu) and Pliocene (?) rocks (Tp) east of Fresno Canyon. The projected trace of the Chino fault trends diagonally across the photo parallel to and beyond the spillway through the clump of trees in right middle distance. Observer faces northeast. *Photograph by Pictorial Crafts, Incorporated, San Bernardino, California, 1953.*

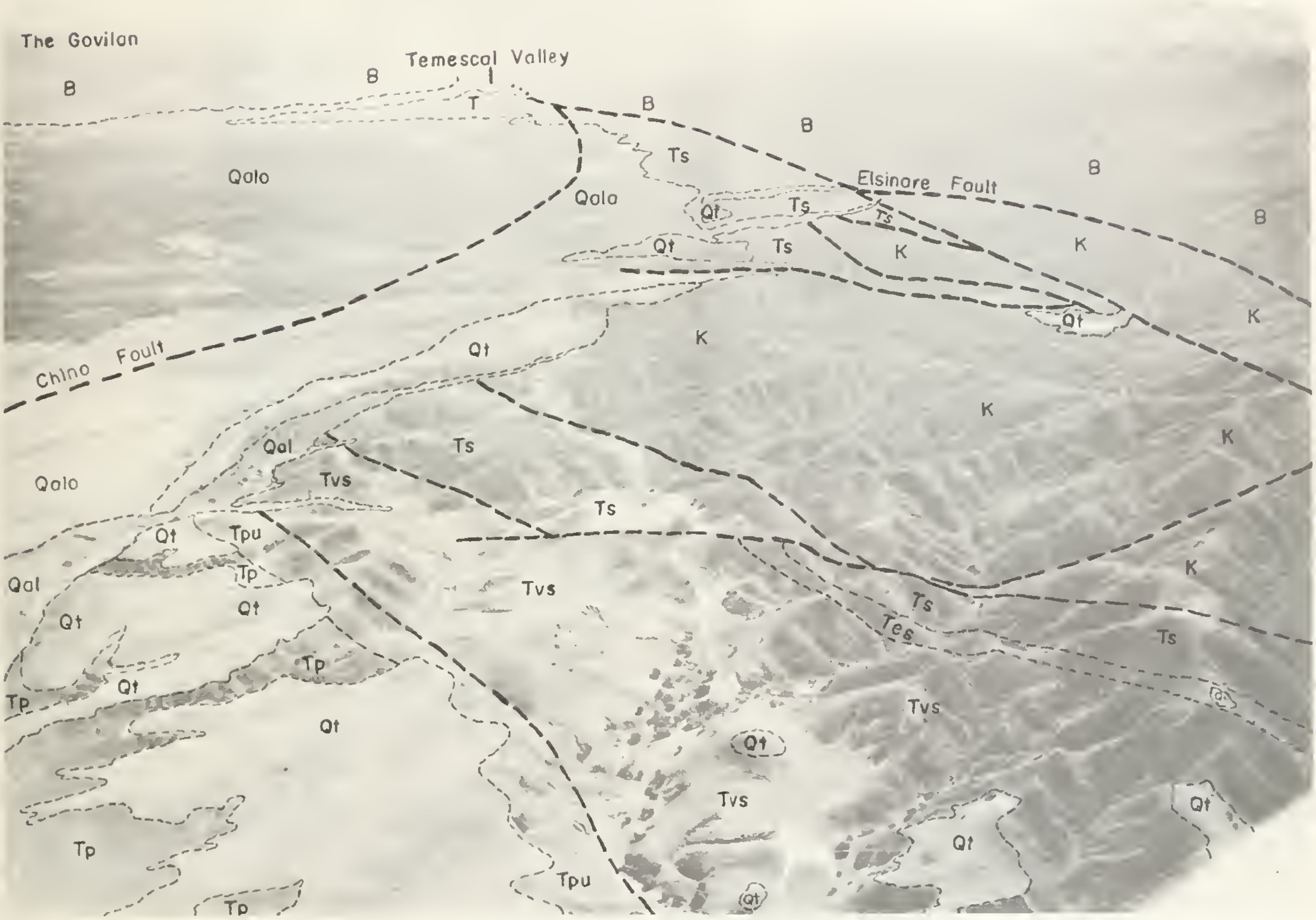

Figure 40. Oblique air photo of the Elsinore fault zone showing generalized geology at the northwest end of the Corona-Elsinore trough (left middle distance) and the northeast flank of the Santa Ana Mountains (right) taken in 1957, camera facing southeast. Qal = Quaternary alluvium, Qalo = older alluvium, Qt = terrace deposits, Tp = Pliocene (?) sediments, Tpu = Puente formation, undifferentiated, Tvs = Vaqueros and Sespe formations, undifferentiated, Tes = Santiago formation, Ts = Silverado formation, T = Tertiary sediments including the Silverado, Vaqueros and Sespe, and Puente formations, and Pliocene (?) strata; and terrace deposits and older alluvium, K = Upper Cretaceous sediments including the Ladd and Trabuco formations, B = basement complex including intrusive, volcanic and metasedimentary rocks. *Photograph by U. S. Geological Survey.*

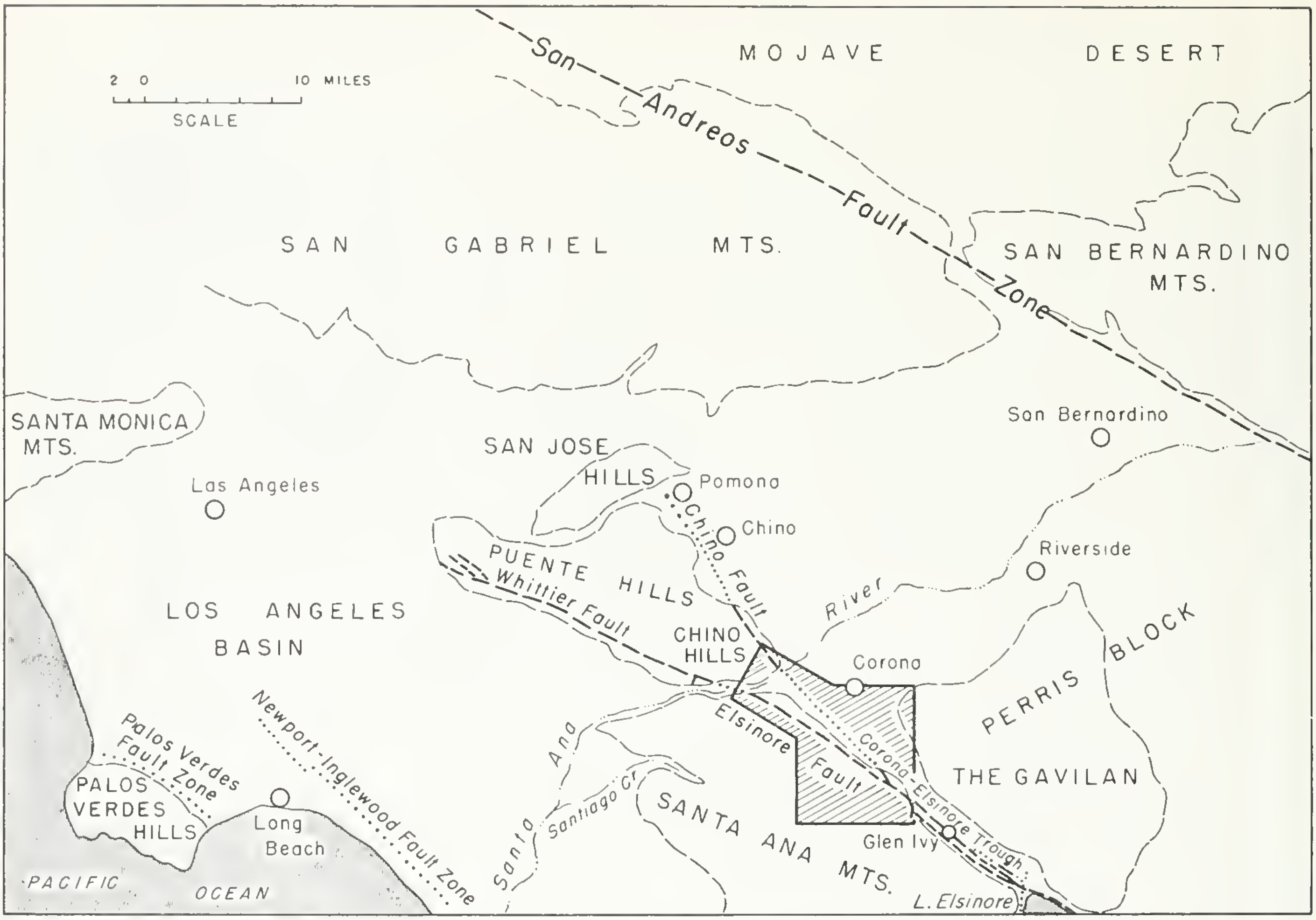

FIGURE 41. Index map of the Corona region, showing major structural features and major faults in a portion of southern California.

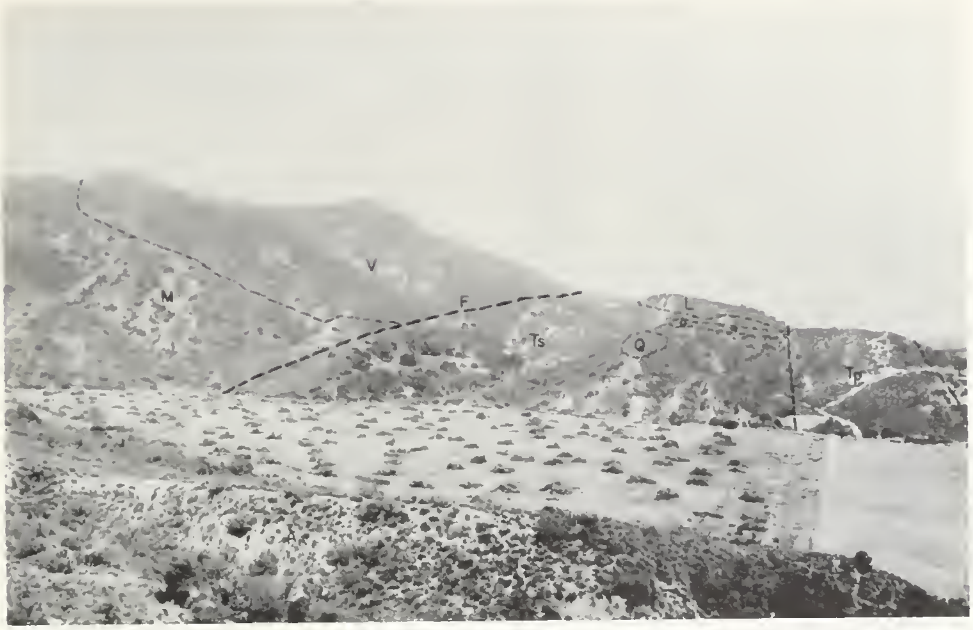

Figure 42. View northwest across Bedford Canyon (middleground) along the Elsinore fault (F). The fault separates Santiago Peak volcanics (V) and Bedford Canyon metasedimentary rocks (M) on the southwest from Tertiary sedimentary rocks (Ts, Silverado formation; Tp, Puente formation, undifferentiated; T, Pliocene, undifferentiated; Q, Terrace deposits) on the northeast. Note landslide mass (L) of Santiago Peak volcanics. Older alluvium (A) in foreground.

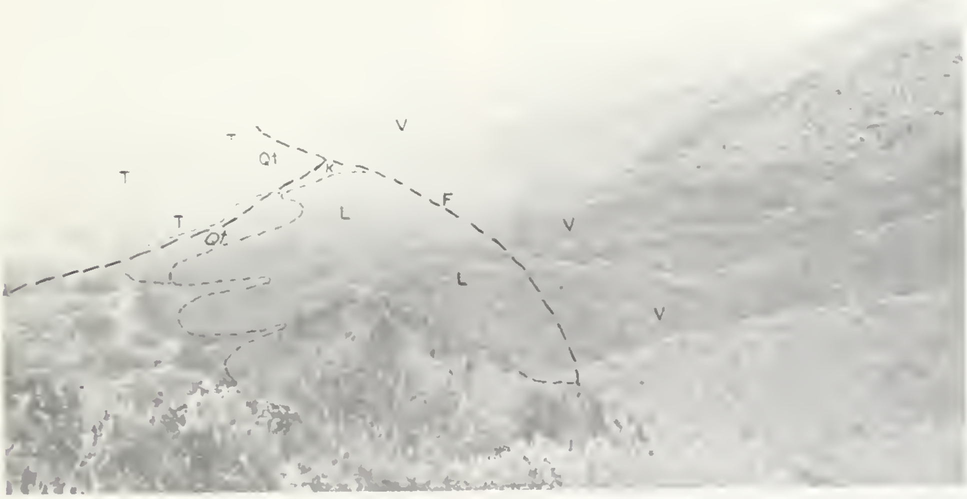

Figure 43. View southeast from Skyline Drive along the Elsinore fault (F). The fault separates Santiago Peak volcanic rock (V) from Tertiary (T) and Cretaceous (K) sedimentary rocks. Note large landslide area (L) of volcanic rock on northeast side of fault and sharply truncated terrace deposit (Qt) in middle distance. Tin Mine Canyon at left. At the east side of Hagador Canyon (middle distance) a fault that separates Cretaceous and Tertiary sedimentary rocks joins the Elsinore fault.

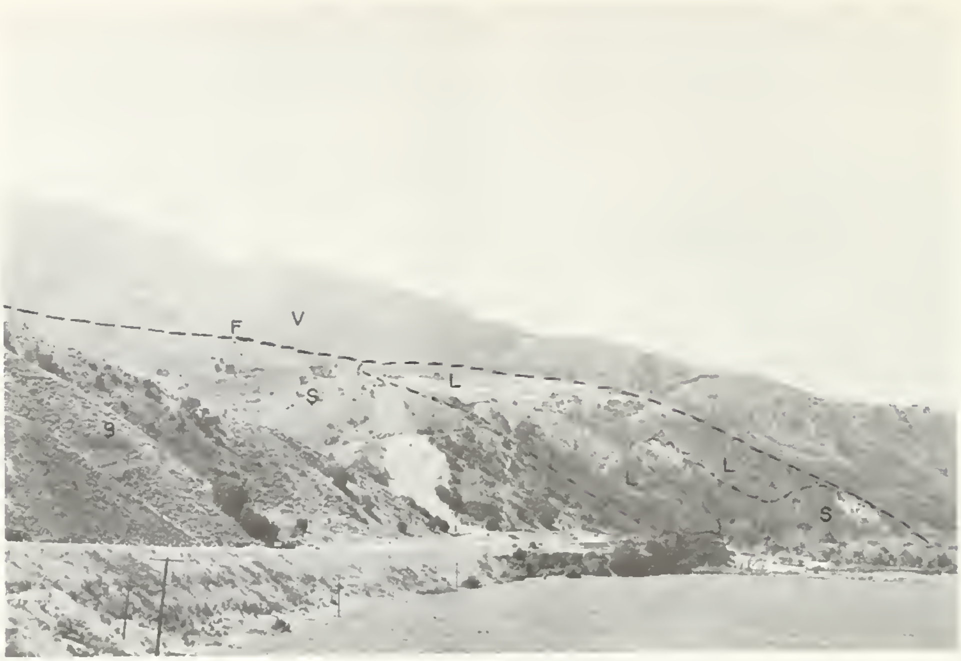

Figure 44. View southwest across the Santa Ana River course toward the Elsinore fault (F) in the Santa Ana narrows area. The fault separates Santiago Peak volcanic rock (V) on the southwest from Cretaceous and Tertiary sedimentary rocks (S) on the northeast. Note large landslide area (L) of volcanic rock.

Temescal Valley. It may be an offset segment of the Elsinore fault or may form the west side of a graben which is bounded on the east by an alluvium-covered portion of the Elsinore fault. This frontal fault, which extends southeastward at least 7 miles beyond the mapped area to a point south of Alberhill, is terminated on the west (in Brown Canyon) by a cross fault which apparently has stepped back this frontal fault as a southwesterly offset segment of the Elsinore fault half a mile to the northwest. Fault features in Temescal Valley are aligned with the northwest segment of the frontal Elsinore fault. Minor movement, more recent than the movement on the frontal fault, apparently has produced the fault features in Temescal Valley. This fault segment apparently joins the stepped-back frontal segment of the Elsinore fault at a point south of Alberhill, about 6½ miles beyond the mapped area.

In the mapped area, northwest of Brown Canyon, the Elsinore fault separates Santiago Peak volcanics and Bedford Canyon metamorphic rocks on the southwest from Cretaceous and Tertiary sedimentary rocks on the northeast. Southeast of Brown Canyon the fault trace is entirely in the Quaternary alluvium and terrace deposits of the Temescal Valley. Along the southwest margin of Temescal Valley an offset segment of the fault separates San Marcos gabbro from the alluviated valley. Many large landslide masses of the basement rock occur along the fault and obscure its trace. In most exposures the trace of the fault is marked by a zone of thoroughly crushed and pulverized basement rock several hundred feet thick, rather than by a single plane. However, along the Corona Skyline Drive, north of Tin Mine Canyon, an exposure of volcanic rock shows a smooth surface that may be the fault plane. Here the fault appears to be either vertical, or steeply-dipping southwestward into the mountains. No slickensides or other features that would indicate the direction of movement were observed. The only other possible exposure of the fault plane was found east of Bedford Canyon in a clay pit. Here too the fault appears to be vertical or to dip steeply to the southwest.

Although the Elsinore fault is not well exposed, its approximate location is shown in the linear alignment of numerous springs and vegetational differences, the wide shear zone of fractured basement rocks, and the local occurence of minor fault scarps in the basement rocks and in Quaternary rocks.

The nature of the movement along the Elsinore fault zone has long been in controversy. Eckis (1934, p. 76) believed that the Santa Ana Mountains had been uplifted on a series of normal faults along the northeast edge of the mountains. According to Engel (quoted in Eckis, 1934, p. 76), ". . . the faults of the Elsinore zone are almost exclusively normal." However, Sutherland (1935, p. 75) thought that the "Whittier-Elsinore fracture zone" was primarily a system of reverse faults. R. H. Jahns has suggested (oral communication, September 1958) that the earliest movement—probably in the Upper Cretaceous to lower Tertiary time interval—was predominantly in a lateral sense. Lateral movement, Jahns believes, is suggested by the straightness of the trace of the Elsinore fault zone, its parallelism with the San Andreas fault zone along which lateral movement has been demonstrated (Hill and Dibblee, 1953, p. 443-458) and the juxtaposition along the Elsinore fault zone, southeast of the Corona area, of dissimilar plutons of the southern California batholith.

The distribution of Cretaceous and Paleocene strata suggests lateral movement. Southeast of Santa Ana Canyon Cretaceous and Paleocene strata, in fault contact, are exposed on the northeast side of the Elsinore fault. Approximately 1½ miles to the northwest, on the southwest side of the projected trace of the Elsinore and Whittier faults, Schoellhamer and others (1954, pl. 1) show Cretaceous and Paleocene strata in depositional contact.

The evidence within the area mapped by the writer has permitted no conclusions regarding the antiquity or earliest sense of movement of the Elsinore fault zone, but it does strongly suggest that, since lower Tertiary time, the Elsinore fault has been a plane of reverse dip separation.* A steep southwest dip is suggested by the trace of the fault in irregular topography.

In the vicinity of Fresno Canyon, and southeastward across the Corona South quadrangle, lateral movement in post lower Tertiary time becomes improbable as it would seemingly have produced a much straighter trace than the fault apparently shows. Indeed, at a locality just west of Fresno Canyon the trace of the Elsinore fault is offset by a later fault. Earlier lateral movement and later deformation of the fault plane could produce the irregularities. Moreover, the preservation of the Arena Blanca syncline as a continuous feature adjacent to the Elsinore fault would be difficult to envision if large lateral movement had occurred on the fault since Plio-Pleistocene time.

Much less conclusive evidence against lateral movement is the juxtaposition along Bedford Canyon of masses of Bedford Canyon formation overlain by prebatholith volcanic rocks and the similarity of the clasts in the sedimentary rocks, especially those in the Cretaceous strata, with the basement rock types that lie immediately across the fault. This may not be significant, however, because of the widespread occurrence in southern California of lithologically similar Bedford Canyon strata and the clasts in the Cretaceous sediments are of common and widespread rock types. The evidence against strike separation is not conclusive enough to preclude post lower Tertiary horizontal shifts of one or two miles.

An accurate calculation of the amount of vertical displacement on the Elsinore fault does not seem possible on the basis of evidence within the mapped area. As Cretaceous sedimentary rocks of the Ladd formation cap the crest of the mountains at the head of Tin Mine Canyon at an elevation of 2,750 feet and the same Cretaceous units are found low along the northeast side of the mountains at elevations as low as 1,250 feet, a vertical separation of 1,500 feet is suggested.

Larsen (1948, map) shows granodiorite and volcanic rock of the basement complex at elevations above 5,000 feet near Santiago Peak southeast of the mapped area. Well records from the eastern part of the mapped area indicate that diorite and quartz monzonite were penetrated at elevations near sea level. These few well records suggest that in the Bedford Canyon-Brown Canyon area the basement rocks have a relatively flat surface that dips gently southwestward. The widespread occurrence of post-Cretaceous residual clay also suggests a low, nearly flat surface. If an essentially planar, pre-Paleocene surface was developed on the basement rocks in the area now traversed by the Elsinore fault, a vertical displacement of greater than 5,000 feet is suggested for this southern portion of the fault.

Chino Fault

The Chino fault cuts across the northeastern slope of the Puente-Chino Hills. Within the mapped part of the Puente-Chino Hills it strikes N. 35° to 45° W. and dips about 55° SW. It is apparently a reverse fault and places Miocene sedimentary rocks over Pliocene (?) strata. Southeast of the Puente-Chino Hills the fault is largely or wholly hidden beneath alluvium, but its projected course appears to gradually converge upon and to perhaps eventually join the Elsinore fault. Sharp differences in groundwater levels in water wells on La Sierra Stock Ranch near State Highway 18, as well as topographic features (chiefly anomalous, narrow trenches) indicate that the fault may cross the Santa Ana River and extend southeast of Highway 18 along the first major wash cut in the older alluvium east of Wardlow Wash. Farther southeast, along the margin of the Santa Ana Mountains, the chief evidence for the Chino fault is topographic. A well-defined scarp at the contact between terrace deposits and older alluvium may be the surface expression of the Chino fault. Its trace also may coincide with anomalous scarplets and benches, especially between Mabey and Main Street Canyons, and with offset drainage lines in the streams between Main Street and Joseph Canyons. The southeastward projection of the trace of the Chino fault from its easternmost exposure in the Puente-Chino Hills suggests that the Chino fault joins one of the faults parallel to the Elsinore fault west of Bedford Canyon and thence joins the Elsinore fault between Bedford and Brown Canyons.

In the Corona region the displacement along the Chino fault may be much greater than that along the Elsinore fault. Indeed, west of McBribe Canyon, the latter may be a horse-tailing extension of the Whittier fault, which, according to Woodford and others (1954, p. 75), is exposed to the northwest in the southern Puente Hills and trends about N. 70° W. for about 25 miles from the Santa Ana River to Whittier. Nearly 8 miles of strike separation, in a right lateral sense, along the Chino fault is suggested by the disposition of two lithologically similar occurrences of the Vaqueros and Sespe formations—one in the northwest corner and the other in the east central portion of the Corona South quadrangle.

These localities are on opposite sides of the projected course of the Chino fault, but are separated by an area almost 7 miles wide which is underlain by younger sedimentary beds. Somewhat similar relations exist for Pliocene (?) and Paleocene strata. Thus such lateral movement, if actual, may date from Paleocene time as the Silverado formation of this age is affected, but most of the movement probably would have occurred since Pliocene time as the seeming offset of Pliocene (?) beds is almost as much as that of the earlier rocks.

However, several features point against lateral movement along the Chino fault. (1) The Arena Blanca syncline extends across the projected fault trace with no apparent lateral offset. (2) Perhaps the most compelling evidence against lateral movement was found at a locality several miles northwest of the highway cut noted

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* In this paper the fault classification terms follow those recently proposed by M. L. Hill (1958, p. 1688) in order to eliminate confusion between separation (apparent relative movement) and slip (actual relative movement).

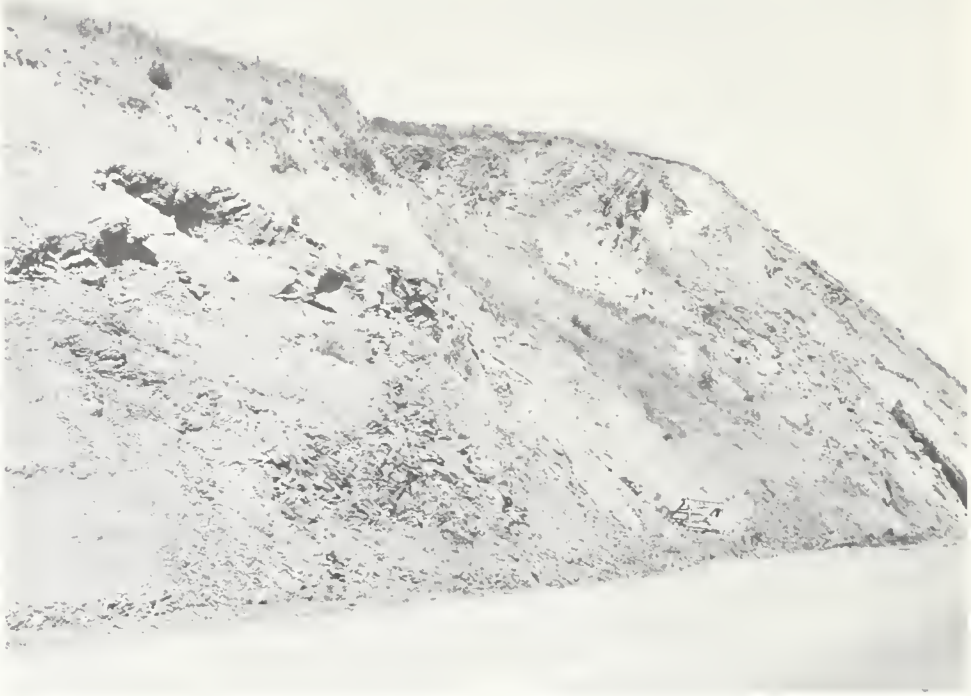


FIGURE 45. Chino fault exposed in cut, west side of State Highway 71 about 1¼ miles north of Prado Dam. The fault (center, left of danger sign) separates siltstone and shale of the Sycamore Canyon member of the Puente formation (left) from Pliocene (?) siltstone and sandstone (right). Observer faces northwest.

below. Here fossiliferous middle Puente sandstone strata, which rest on both sides of the fault and have been encountered in wells, are apparently not offset laterally (oral communication, R. F. Yerkes, 1957). Several additional, but less significant features, tend to support this evidence. (1) The general distribution of the Bedford Canyon formation, already noted in the description of the Elsinore fault, requires no lateral movement. (2) Minor drag folds, which are well exposed on both sides of the Chino fault in the road cut on State Highway 71,

FIGURE 46. Vertical to steeply west-dipping shear zone exposed underground in water tunnel north of Bixby Canyon. The fault (left of hammer) separates brecciated intrusive rock at left (phase of the San Marcos Gabbro) from Bedford Canyon formation graywacke (right). Observer faces south.

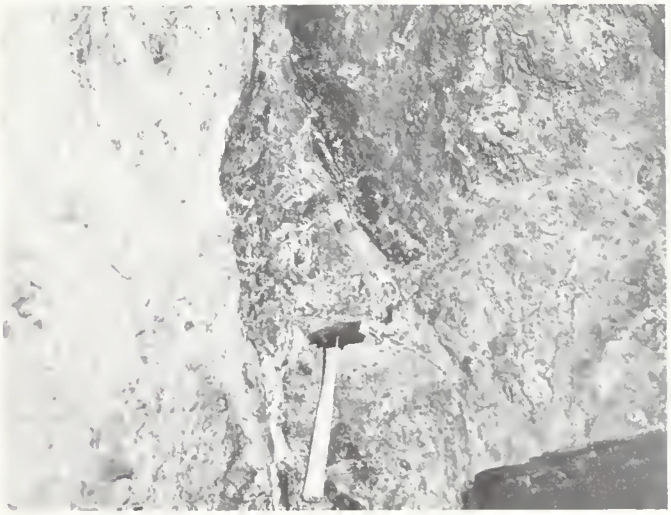
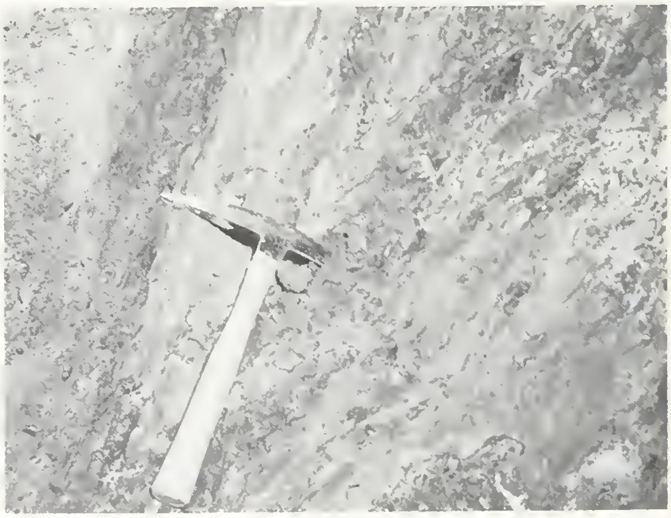


FIGURE 47. Closeup of vertical shear zone in Bedford Canyon formation graywacke. Hammer point marks gouge zone. Exposure underground in water tunnel north of Bixby Canyon. Observer faces south.



have amplitudes of about 8 inches and horizontal axes, which favors dip-separation movement. Thus lateral movement along the Chino fault, at least since middle Puente time (upper Miocene), seems improbable.

Minor Faults

A number of minor faults have been mapped. Most are apparently vertical or high-angle reverse and are remarkably parallel to the Elsinore fault. Some are cross faults, most of which are apparently vertical and have only a few hundred feet of displacement. A few cross faults have an equally small apparent lateral offset.

Cross faults at large angles with the Elsinore and Chino fault systems complicate the structural pattern of the area. Northwest of Tin Mine Canyon a group of cross faults, each with an apparent lateral movement of only a few hundred feet, have greatly disturbed clay beds in the Silverado formation. West of Fresno Canyon a cross fault with apparent horizontal movement has offset the basement rocks about 1,000 feet and has also apparently offset the Elsinore fault. In Brown Canyon the Elsinore fault is apparently offset nearly 2,600 feet by a north-northeast-trending vertical or high-angle reverse cross fault (figs. 46, 47).

The cross faults probably are tear faults. They may be caused by the same compressional forces that apparently produced the major northwestward-trending reverse faults of the area. The cross faults also may be an effect of jostling at a time (possibly lower Tertiary) when movement on the Elsinore fault may have changed from lateral to high-angle reverse. The horizontal offsets on the Elsinore fault, especially the offset at Brown Canyon, may be only apparent. The apparent offset block may have dropped between the continuation of the original Elsinore fault and a more southwesterly vertical fault and be a product of vertical movement along the fault zone.

On Scully Hill a normal fault of little apparent displacement separates La Vida and Soquel members of the Puente formation. This fault, herein designated the Scully Hill fault, may cross the Santa Ana River and assume an easterly and southeasterly course, subparallel to the Elsinore fault, as far as Wardlow Wash to the southeast of which it appears to extend beneath Quaternary deposits and has a course nearly parallel to that of the Chino fault. West of Wardlow Wash this fault has been interpreted as marking the contact between Vaqueros-Sespe and Puente strata. The Topanga formation and probably part of the Puente formation are, therefore, missing. These relationships are possibly attributable to an unconformity, but the linear trace of the contact, its alignment with faulting to the west, and a high degree of deformation in the bordering rocks strongly suggest a fault contact. If this is true, then this fault must have a vertical separation of about 1,000 feet, which is the minimum thickness of the missing strata.

A set of vertical or high-angle reverse faults lies parallel to and northeast of the Elsinore fault on its apparent downthrown side. These faults probably are sympathetic to the main fault and belong to the Elsinore fault zone. Two such faults extend eastward from Santa Ana Canyon. A third fault branches from the Elsinore fault from a point on the east side of Hagador Canyon and thence extends northwestward nearly parallel to the Elsinore fault. It is better defined to the northwest, chiefly by topographic features including small fault sags and aligned saddles, but also by differences in rock types encountered in the drilling of two water wells closely spaced on either side of the fault, in the vicinity of Mabey Canyon. Northwestward this fault extends beneath terrace deposits at a locality on the east side of Fresno Canyon. In the eastern part of the mapped area, in the vicinity of Bedford and Brown Canyons, several vertical north to north-northwest-trending faults of unknown displacement have greatly disturbed the Tertiary sedimentary rocks.

Age of Faulting

The most compelling evidence in the mapped area suggests that the initiation of predominantly vertical movement along the Elsinore and Chino faults commenced prior to late Pleistocene time. That it probably occurred mostly in late Pliocene and early Pleistocene time is strongly suggested by the marked unconformity between Quarternary terrace deposits and highly deformed Pliocene (?) strata. However, geomorphic and topographic features, including aligned scarplets and trenches, as well as anomalous drainage lines, scarps, and benches, indicate the movement has continued into Recent time. That the movement has been discontinuous is shown by the extensive occurrence of terrace surfaces at different elevations. At least some of the faults that parallel the Elsinore fault are believed to have been active more recently than it. West of Fresno Canyon, for example, a cross fault offsets the Elsinore fault but is in turn cut by a fault that, west of Fresno Canyon, parallels the Elsinore fault, thus showing both of these faults to have moved more recently than the Elsinore fault. The last-mentioned fault apparently cuts off still another fault parallel to the Elsinore fault east of Fresno Canyon.

Evidence for pre-Pliocene movement exists but is not conclusive. Cretaceous strata apparently are not present in the Corona-Chino valley or Puente-Chino Hills blocks. This gap in the sedimentary record suggests the possibility of a period of strong deformation from post Upper Cretaceous time through pre-Pliocene time or even pre-Upper Cretaceous deformation. If Cretaceous sedimentary rocks did exist in these blocks, as is strongly suggested by the abrupt termination south of Santa Ana River and west of Wardlow Wash of extensive Cretaceous strata, then a post-Upper Cretaceous pre-Miocene uplift may well have occurred along the Elsinore and Chino fault systems. Such movement would have been reverse to that which appears to have characterized late Pliocene or Pleistocene time and Recent time and may have caused the Cretaceous beds to be stripped from the Corona-Chino valley and Puente-Chino Hills blocks. During Cretaceous time, however, these blocks may have been structural highs which received no sediments and were perhaps elevated or moved laterally by Cretaceous or pre-Cretaceous faulting.

Relationship Between the Elsinore, Whittier, and Chino Faults

The question of whether or not the Elsinore fault extends northwestward to join the Whittier fault across the Santa Ana River has aroused much interest. The

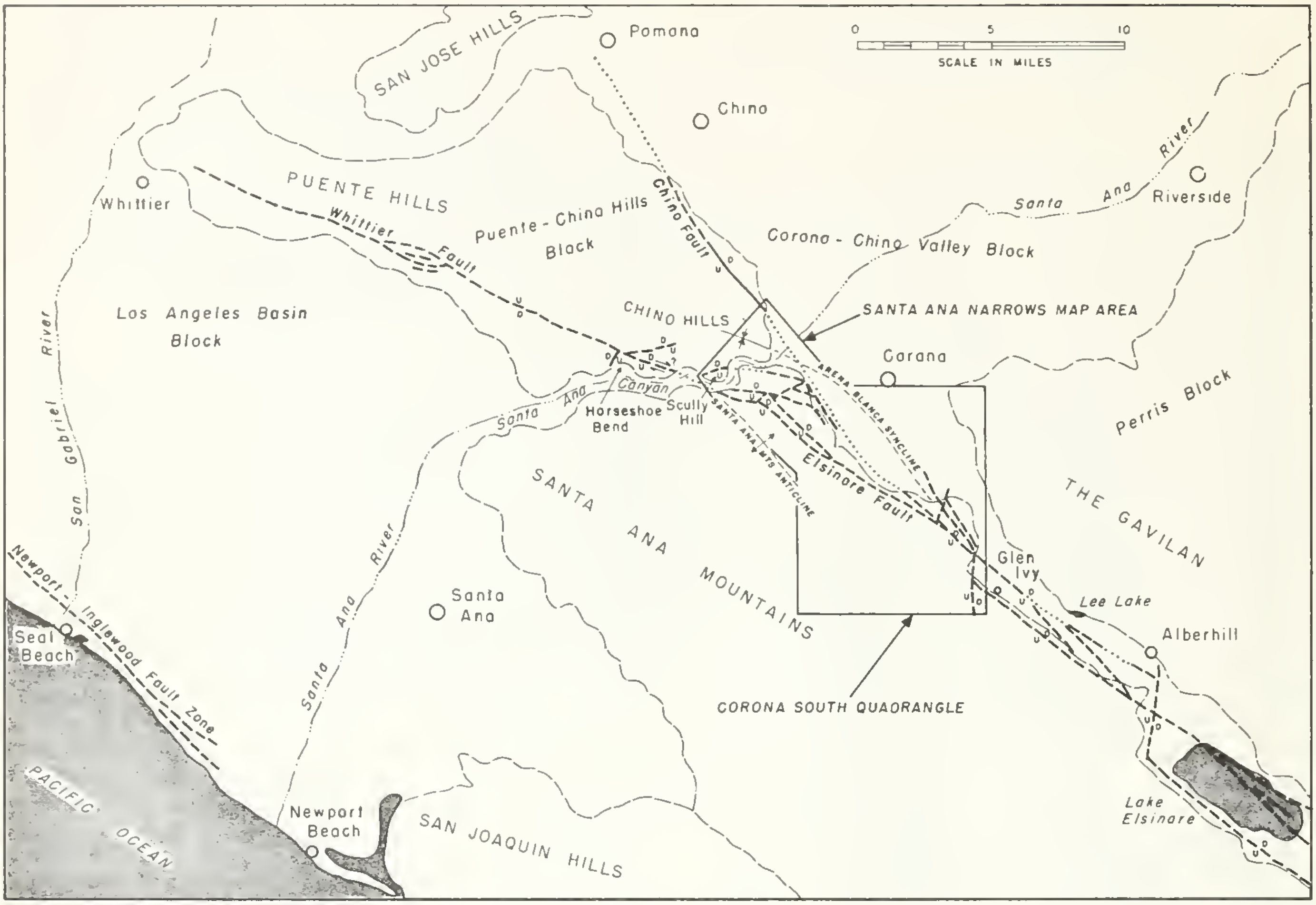


FIGURE 48. Sketch map showing major structural features of the Corona area and their probable relation to adjacent portions of southern California.

Whittier fault is generally considered to have at least a small component of lateral movement, whereas, in the mapped area, the Elsinore fault, at least since lower Tertiary time, apparently has none. According to Woodford and others (1954, p. 75) the major segment of the Whittier fault appears to be upthrown on the northeast side. This relationship persists northwestward from a cross fault at the west edge of Horseshoe Bend which is on the Santa Ana River and about 3 miles west of the mapped area (fig. 48). In the Corona area the Elsinore fault is apparently downthrown on the northeast. Woodford and others (1954, p. 75) suggest that from the Horseshoe Bend cross fault southeast about 3 miles to a point on the Santa Ana River where the projected trace of the Whittier fault and the river intersect, the Whittier fault is characterized by movement with a lateral component as well as a component of dip separation with the apparent displacement downward on the northeast side.

Nearly 3 miles of strike separation, in a right lateral sense, is suggested by two similar occurrences of Puente and Topanga strata—one on the northeast side of the Whittier fault at Scully Hill (pl. 3; fig. 48) and the other on the southwest side of the fault at Horseshoe Bend (see Schoellhamer and others, 1954, pl. 1). If this suggested lateral offset is actual, then, as pointed out by Woodford and others (1954, p. 75), the Scully Hill fault and the northeast-trending Horseshoe Bend cross fault may be offset segments of the same fault. Moreover, the Whittier fault in this area apparently has at least a small component of dip-separation which dies out southeastward toward the Santa Ana River. The amount of displacement is not known, but, inasmuch as the Whittier fault appears to cut out the Soquel and La Vida members of the Puente formation southeast of Horseshoe Bend (Schoellhamer and others, 1954, pl. 1) the dip-separation component may be of the order of 5,000 feet in the eastern Puente-Chino Hills.

The relationships described above suggest that in Plio-Pleistocene time the Puente-Chino Hills block may have been pushed southeastward along the Whittier fault and was also elevated relative to the Los Angeles Basin. At the same time the Santa Ana Mountains block was rising and also perhaps moving slightly northwestward. Apparently the three structural blocks—the sinking Los Angeles Basin and the two, wholly independent, rising blocks (fig. 48)—meet at the Santa Ana narrows to produce a rotational movement along the Whittier and Elsinore fault zone. From evidence in the mapped area lateral movement, at least since lower Tertiary time, does not appear to have extended southeast of the Santa Ana River. As already stated, much greater dip-separation movement on the Elsinore fault is suggested in the eastern part of the Corona region than in the vicinity of Santa Ana Canyon so that vertical displacement may be relatively small in the Santa Ana narrows.

The southeastern part of the Puente-Chino Hills block, bounded by the steeply dipping to vertical Whittier-Elsinore fault zone on the southwest and by the moderately southwest-dipping Chino fault on the northeast, appears to be a giant wedge that tapers southeastward and downward. The evidence for right-lateral movement as well as evidence for dip separation at the eastern end of the Whittier fault and for reverse movement along the Chino fault suggest that the wedge moved prow-like eastward and concurrently upward on its northeast side. This suggested movement also may have caused the southeastern margin of the wedge to be rotated downward with respect to the Santa Ana Mountains block. If the wedge did move in this manner, the writer would ordinarily expect the strata along its margins and especially at its apex to be highly contorted. The lack of extreme disorder in these strata may be attributable to the relief of compression by the upward movement along the Chino fault.

An extension of the Whittier fault eastward along the trend mapped by Woodford and others (1944, map) and Schoellhamer and others (1954, pl. 1) would join the Elsinore fault, or one of the faults parallel to it, at a locality southeast of the Santa Ana River where Cretaceous and Paleocene sedimentary rocks are greatly contorted by faulting. However, the Horseshoe Bend cross fault, where there is apparently an abrupt reversal of the displacement on the Whittier fault, was previously thought likely to terminate the Whittier fault (Woodford and others, 1954, p. 75). Recent mapping indicates this is not the termination and that the Whittier fault continues southeast past Horseshoe Bend to the Santa Ana River (oral communication, R. F. Yerkes, 1957), and that along this part of its trace the Whittier fault has caused the block on its southwest side to move upward (Woodford and others, 1954, pl. 1). Thus, in the area of the Santa Ana River, the relative movement on the Elsinore and Whittier faults is the same. If the trace of each fault is projected across the river, they coincide. If the Elsinore and Whittier faults do not join to form a single, continuous break across the Santa Ana River, the Whittier fault probably splits and frays out into the Elsinore fault zone.

The Chino fault probably is continuous with a fault that intersects the Elsinore fault near McBribe Canyon, midway between Bedford and Brown Canyons, but this has not been fully demonstrated. If the Chino fault is not continuous with this or one of the other northwest-trending faults in the Bedford Canyon-Brown Canyon area, it must die out beneath the older alluvium south of Corona, as no other fault zone that could join the Chino fault was found in the northeastern quarter of the Corona South quadrangle. However, topographic features, chiefly scarplets; and anomalous drainage lines, scarps, and benches, strongly suggest that a fault borders the lower margin of the Santa Ana Mountains south of Corona. If so, this fault appears to intersect the Elsinore fault between Bedford and Brown Canyons, and may well be the southeastward extension of the Chino fault. If this is the Chino fault, then it and the Elsinore fault bound the southeastern part of the wedge-shaped fault block—the Puente-Chino Hills block—that extends northwestward from Bedford Canyon into the Puente-Chino Hills.

Folds

The rocks along the northeastern flank of the Santa Ana Mountains strike, in general, N. 50° to 70° W. to form folds approximately parallel to the Elsinore fault and to the trend of the mountains. Dips range mostly from 30° to vertical, and have an estimated average of about 60°. In a few places Tertiary beds are horizontal or very gently dipping. Most of the observed dips are to the northeast, although local and marked differences in dip suggest repetition of the beds in a series of minor folds. Overturned beds and vertical beds are common, particularly near the Elsinore fault. Indeed, all of the Silverado strata between Main Street and Hagador Canyons may be overturned. These commonly show dips of 45° to 65° SW. and at a few localities they are vertical.

Along the southeastern tip of the Puente-Chino Hills Tertiary sedimentary rocks strike from N. 70° W. to N. 80° E. and at many places strike nearly west. South and west of Prado Dam the strata dip consistently to the north or northeast, whereas a short distance north of Prado Dam, across the axis of the Arena Blanca syncline, the dips are to the south or southwest. The axial trace of the syncline trends approximately N. 70° W. This syncline is asymmetrical, in that the north limb dips about 35° and the south limb averages about 60°. The syncline appears to plunge to the northwest.

Southeast of Corona, along the west side of Bedford Canyon, scattered patches of Miocene and Pliocene (?) sedimentary rocks form part of a syncline which has been broken by faulting. This syncline also is asymmetrical. Vertical to steeply northeast-dipping beds are exposed on the south limb and strata on the north limb dip about 35° SW. It apparently plunges northwestward and is probably the faulted and eroded remnant of the Arena Blanca syncline of the Puente-Chino Hills. Farther east, along Brown Canyon, Paleocene Silverado beds, upper Eocene to lower Miocene (?) Vaqueros-Sespe beds, and upper Miocene Puente beds form a shallow and narrow synclinal remnant. The sedimentary record suggests that the eastern margin of a narrow basin of Tertiary deposition—probably an arm of the Los Angeles Basin—was near Brown Canyon.

Cretaceous and Tertiary sedimentary rocks constitute the southwestern flank of the Santa Ana Mountains and, in general, dip southwestward to westward off of the basement rocks that form the crest of the mountains (Schoellhamer and others, 1954). On the northeast and north flank of the Santa Ana Mountains the Cretaceous and Paleocene strata dip generally northeastward to northward. These strata, therefore, have the form of a great northwestward-trending anticline. The crest of the anticline approximates the crest of the mountains, and has been broken, slightly east of its axis, by movement on the Elsinore fault. Remnants of the northeast limb of this anticline, although highly faulted, occur along the northeastern flank of the Santa Ana Mountains in the Corona region and remain as the southwest limb of the Arena Blanca syncline.

Elsinore Trough or Graben

Temescal Canyon (locally termed Temescal Valley) is an irregular valley from 1½ to 3 miles in width and about 20 miles in length, extending from Corona to Elsinore. It is often referred to as the Elsinore trough or graben. This trough is the northwest part of a valley-like region about 40 miles long which extends southeastward from Corona to a point beyond Temecula. The entire feature is commonly termed the Elsinore-Temecula trough. In the Corona region the trough superficially resembles a graben, but northwest of Brown Canyon no fault was found that could mark the northeast side of the graben, and Temescal Canyon appears to be an erosional trough bounded by a young fault zone on its southwest side. To the southeast of the Corona South quadrangle, however, the trough may well be a graben. Recent mapping by Fish (1953, map) and Rogers (1959, pl. 5) as well as a brief field investigation by the writer indicates that the Elsinore fault extends southeastward past Glen Ivy Hot Springs (a third of a mile east of the Corona South quadrangle at the mouth of the Coldwater Canyon), at least to a point about one mile southeast of Lee Lake (3 miles east-southeast of Glen Ivy), and marks the southwestern side of a graben (fig. 48). Rogers shows another fault, nearly parallel to the Elsinore fault, about a quarter of a mile southwest of Lee Lake and with the necessary separation to form a graben. This fault may join with faults of the same separation between Brown Canyon and Bedford Canyon in the eastern part of the Corona South quadrangle. If this is true a graben about half a mile wide may exist east of Bedford Canyon and extend southeastward past Glen Ivy and perhaps beyond Lee Lake.

Conclusions

1. A single break, apparently offset in two places, and with a high-angle reverse dip-separation sense of movement, can be designated as the Elsinore fault.

2. Strike separation along the Elsinore fault has not been proved, within the mapped area, but horizontal shifts in a right lateral sense may have amounted to 1 or 2 miles. Pre-middle Tertiary lateral movement, suggested by the juxtaposition of dissimilar rock types of the Southern California batholith southeast of the mapped area, may have been much greater.

3. The Elsinore and Whittier faults apparently join across the Santa Ana River narrows, where rotation along the fault zone may have occurred.

4. The Chino fault probably is a reverse fault. The southeasterly projection of its trace suggests it joins the Elsinore fault southeast of Corona, east of Bedford Canyon.

5. The major movement along the Elsinore and Chino faults, as indicated by the Tertiary rocks in the mapped area, probably commenced prior to late Pleistocene time and may date from late Pliocene time. The movement has continued into Recent time.

6. The top of the Santa Ana Mountains marks the crest of a great northwest-trending anticline. It is paralleled on the northeast by the Arena Blanca syncline.

7. In the Corona area the Corona-Elsinore trough apparently is a broad valley eroded in poorly consolidated sediments and bounded by a young fault zone on its southwest side.

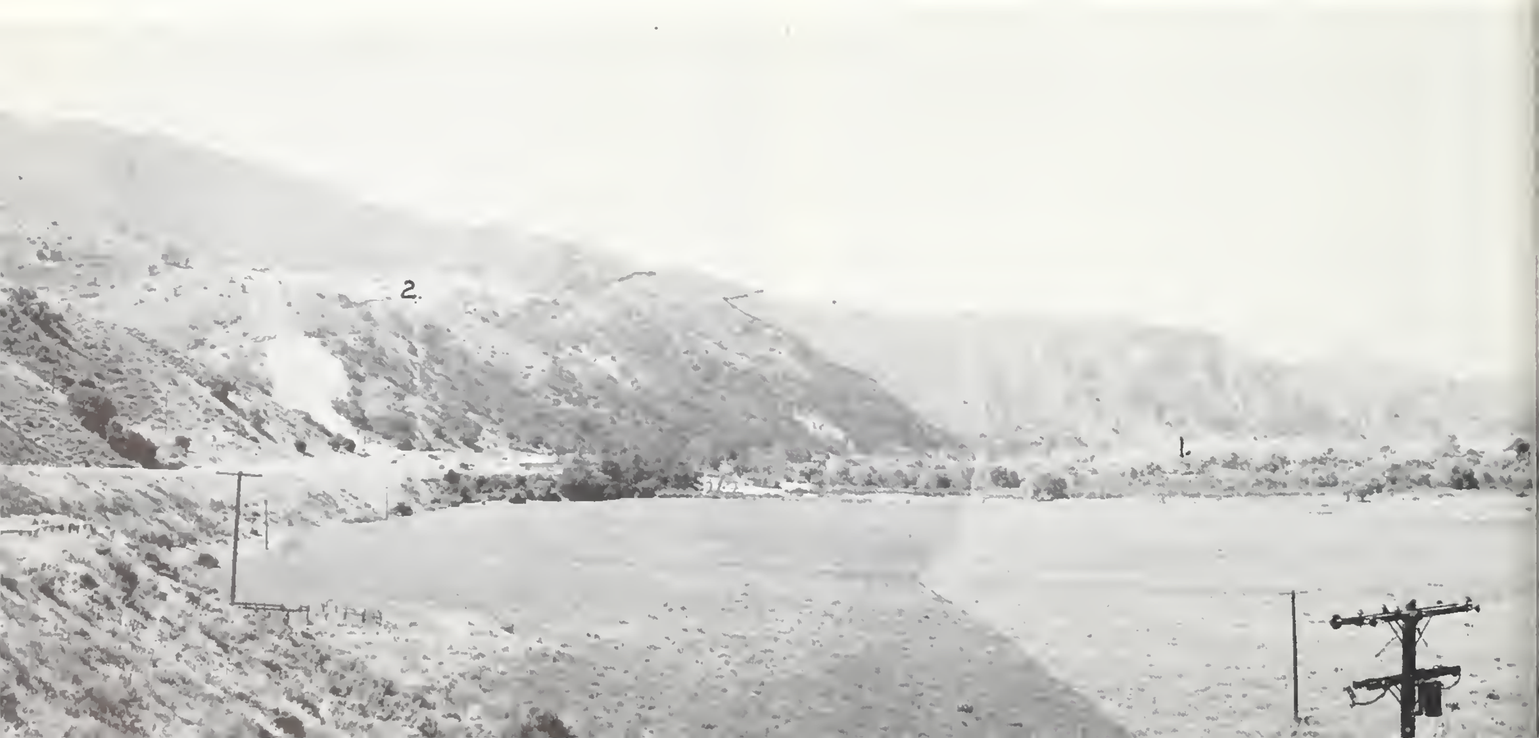


FIGURE 49. View west along the Santa Ana Canyon toward Santa Ana narrows (center). At left are the Santa Ana Mountains. Elsinore fault trace is just behind trees in middle distance at left edge of photo. Flat areas (1) in center beyond the trees and south of the railroad and (2) half way up the mountains at the left are landslides of Santiago Peak volcanic rock. Note landslide cirques at the left in the Santa Ana Mountains. The Puente-Chino Hills are on the right. North of the railroad, Scully Hill is the typical topographic expression of the Miocene sedimentary rocks. From left to right they are: Topanga formation (irregular surface), La Vida (shale) member of the Puente formation (rounded slopes), Soquel (sandstone) member of the Puente formation (irregular surface), Yorba (shale) member of the Puente formation (rounded topography), and the Sycamore Canyon (sandstone and conglomerate) member of the Puente formation (irregular surface above right edge of citrus grove). Sandstone and conglomerate of the Vaqueros and Sespe formations, undifferentiated, exposed at far right, east side of Santa Ana River.

GEOMORPHOLOGY

General Features

The land forms in the Corona area are predominantly block mountains which have been dissected marginally by streams (fig. 40, 49). They are now in a late-youth stage of development.

The most prominent topographic features are expressions of movement along the Elsinore fault. The highest altitude in the mapped area, 4,007 feet, is Pleasants Peak, a point on the crest of the Santa Ana Mountains. This is 3,300 feet above the surface of the compound alluvial fan at Corona and 3,532 feet above the Santa Ana River at Prado Dam. The Santa Ana Mountains block is asymmetrical in profile with the northeast slope steeper and more abrupt than the southwest slope.

The Puente-Chino Hills block, uplifted between the Whittier fault on the south and the Chino fault on the north, has a maximum elevation of 1,781 feet at San Juan Hill, 3 miles west of the mapped area. The Puente-Chino Hills have a relatively gentle topography and the block is more symmetrical than the Santa Ana Mountains block.

Drainage

General Features. The overall drainage pattern is integrated inasmuch as all of the major streams eventually reach the Santa Ana River, to whose level all of the streams are grading. In the Puente-Chino Hills the drainage pattern is dendritic. The tributaries in the Santa Ana Mountains generally enter the major streams at nearly right angles and thus form a trellis or gridiron pattern. Alternate periods of rejuvenation and of aggradation are indicated by the incised stream courses on the Corona alluvial fan. Evidently the one drainage outlet for the area, the Santa Ana River, is aggrading as its bed is filled with nearly one hundred feet of alluvium at Prado Dam. This aggradation has been attributed to a eustatic rise of sea level at the end of Pleistocene time (Poland, 1947).

Stream Types. The smaller streams and tributaries are consequent, but the two major streams, the Santa Ana River and Temescal Creek, are each of a special type.

The Santa Ana River is apparently an antecedent stream that flowed along its present course before uplift of the Puente-Chino Hills and Santa Ana Mountains blocks and was able to maintain its former course across a slowly rising mountain mass. The stream cut into the rising mass throughout the period of deformation, resulting in the Santa Ana narrows. This is suggested by topographic evidence, particularly by small, flat-topped benches or mesas at different elevations along the Santa Ana Mountains side of the river and slightly deformed terraces at different levels. Superposition is not likely because of the distribution and structure of the Tertiary sedimentary rocks. Apparently no uplift is in progress today across the Santa Ana River, as the channel is being alluviated all the way to the ocean (Poland, 1947, p. 4, pl. 7).

Temescal Creek is a fine example of a superimposed stream. This stream has cut a steep cliff face in basement rocks along the northeast side of Temescal Canyon. One might at first suspect that the debouching of fanglomerate material from the Santa Ana Mountains had forced Temescal Creek against the hard rocks and permitted the cutting of Temescal Canyon. However, reference to the geologic map shows that, southeast of Corona, Temescal Creek has cut a gorge wholly in resistant basement rocks. Farther southeast, recent work by Fish (1953, map) and Rogers (1959, pl. 5) shows that Temescal Creek is entirely in basement rocks at Lee Lake and again north of Glen Ivy. This is also true just east of the mapped area. All of these canyons are apparently cut through unfaulted basement rocks. Fish also found deep alluvial fill from elevation 1,000 to 1,574 feet and Rogers assigned part of these outcrops in the Perris Block northwest of Dawson Canyon to the Paleocene Silverado formation. The patchy outcrops of Tertiary sediments and old terrace deposits southeast and east of Corona in the Elsinore trough and on the Perris Block

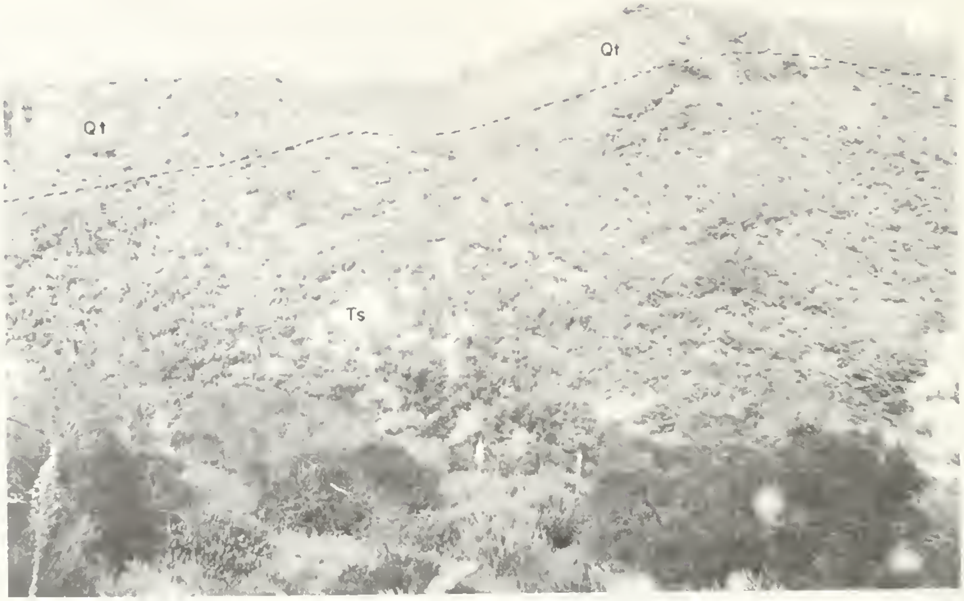


Figure 50. Two levels of terrace deposits (Qt) overlying Silverado formation sandstone and conglomerate (TS) along the east side of lower Hagador Canyon. These two terrace levels have formed by differential erosion. Observer faces east.

indicate that this region was once buried by sedimentary rocks. Apparently in Plio-Pleistocene time Temescal Creek followed a meandering course on these sedimentary rocks and later became superimposed on the resistant basement rocks.

In Plio-Pleistocene time Tertiary sedimentary rocks filled the site of the present Elsinore trough southeast of Corona and, as already indicated, apparently lapped up on the southwestern edge of the Perris Block. These sediments may later have been slightly tilted to the southwest by movement on the Elsinore fault. This tilting may have provided the initial course of Temescal Creek and the creek quickly eroded most of the soft sediments.

Terrace Deposits, Terraces and the Corona Alluvial Fan

Many of the terrace deposits, so well developed along the northeastern flank of the Santa Ana Mountains, have nearly flat surfaces (fig. 52); others have been greatly dissected. Most of the surfaces are nearly horizontal and slope northward or northeastward at 5° or less, but a few slope as much as 15°. The beds of the terrace deposits are generally horizontal or dip less than 5° north or northeast, but some southeast of Bedford Canyon were observed to dip as much as 15°, thus indicating deformation. A number of terraces in the region south of Prado Dam lie at slightly different elevations. Many of these terraces are flattopped ridges with the geomorphic form of an old terrace, but have little or no terrace material deposited on them. Evidently these are denuded benches that never were covered with terrace deposits. They probably were cut by the Santa Ana River and the different levels represent periods of more rapid rise of the mountain block transverse to the Santa Ana River.

Differential erosion and faulting apparently have both been factors in determining the present day elevations of the terrace deposits. Two terrace levels, developed on a once apparently continuous terrace deposit along the east side of Hagador Canyon where no faulting is likely, afford a good example of features formed mostly by differential erosion, which is probably the dominant process (figs. 50, 51). The topographic break between terrace deposits and the older alluvium is probably a scarp along the Chino and several parallel faults. This is most evident south of Corona between Hagador and Main Street Canyons. The material shown as older alluvium may well be merely a thin veneer on the down-dropped portion of a large, pre-existing alluvial fan, and that the terrace deposits are remnants of the upthrown block.

The Corona compound alluvial fan has a typical fanlike drainage pattern. It has been much dissected (fig. 53), and differential erosion has produced many broad and nearly flat surfaces at different elevations. Typical fan head trenches are present and are especially well developed in the Main Street Canyon-Eagle Canyon region. The fan has a general northeast slope which averages about 4° and ranges from 3° south of Corona to 5° along the northwest side of Bedford Canyon.

Landslides

Landslides or slumps occur at many places along the Elsinore fault. They are irregular masses of fractured basement rock that generally rest upon the main rock mass. However, two slides of basement rock are isolated from the mass. The first of these, northwest of Bedford

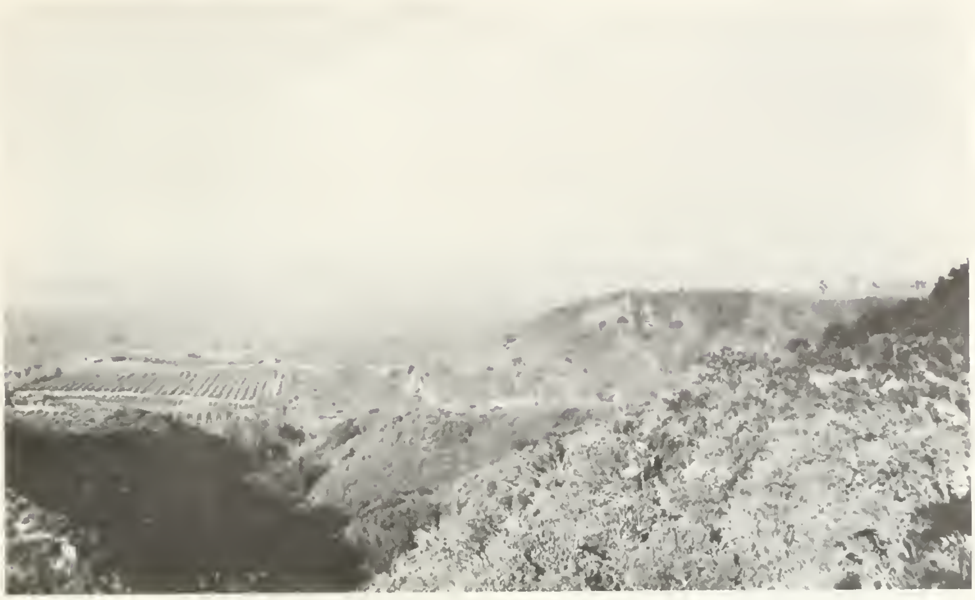


FIGURE 51. View northeast across the northwest end of the Corona-Elsinore trough from Skyline Drive. Temescal or Gavilan Hills (part of Perris Block) in background. Citrus groves in left middle distance are on the Corona compound alluvial fan. Ridge line in center (with trees) is same two terrace levels shown in fig. 50. Brush covered area in foreground is underlain by Ladd formation sandstone and conglomerate and Silverado formation sandstone.

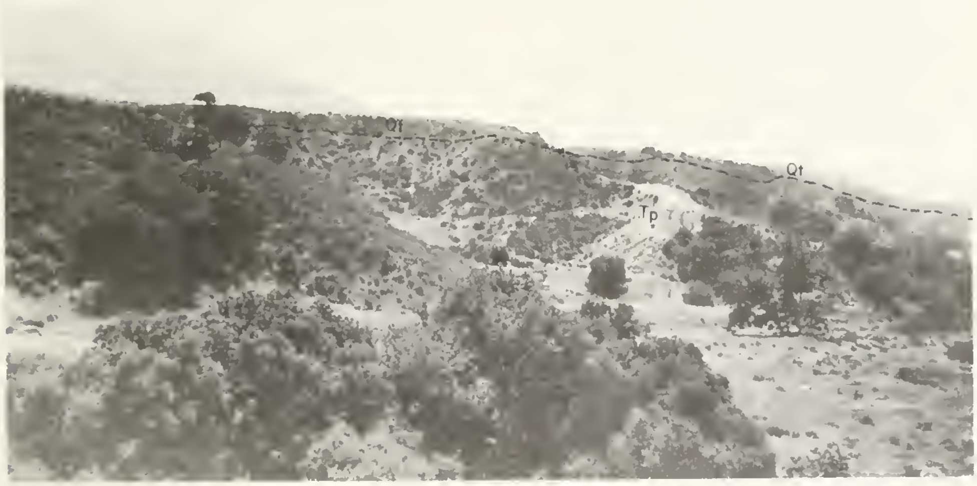


FIGURE 52. Flat-topped terraces southeast of Prado Dam along State Highway 18. Terrace deposits (Qt) overlie white Pliocene (?) sandstone (Tp). White outcrop at right is fossil locality 20. Lower Wardlow Wash in foreground. Observer faces southwest.

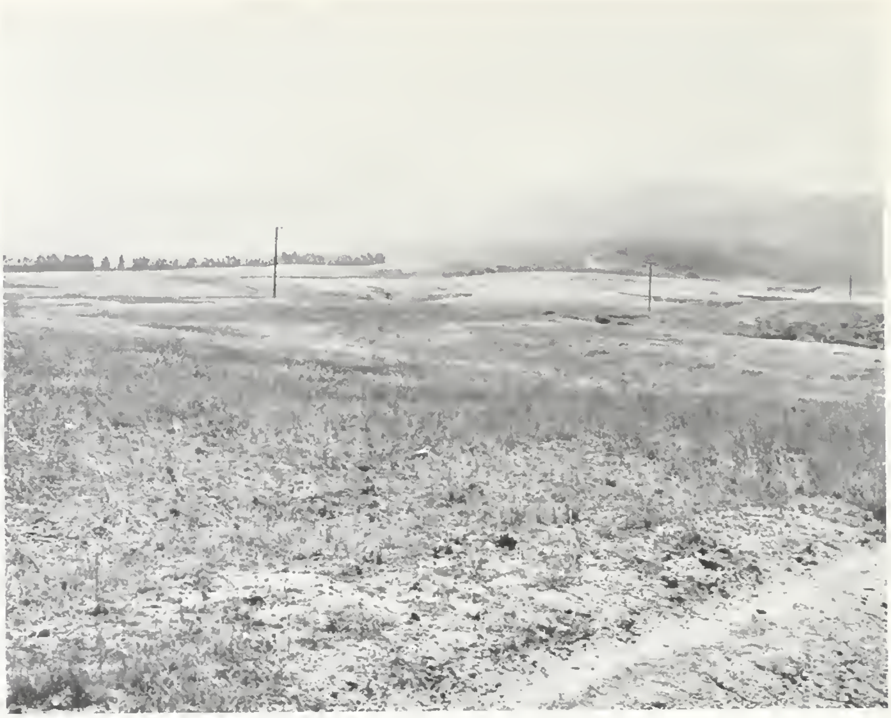


Figure 53. Surfaces of Corona compound alluvial fan. View southeast toward Tin Mine Canyon (center background) and Santa Ana Mountains (background).

Canyon, is a large block of pulverized volcanic rock resting on Paleocene and Miocene sedimentary rocks and surrounded by them (fig. 42). This slide has apparently moved about 1,800 feet horizontally. The other isolated block, composed of volcanic slide material, is in Santa Ana Canyon at the southern margin of Scully Hill. The toe of the slide apparently overrides terrace deposits and sedimentary rocks of the Vaqueros and Sespe formations on the north. The Santa Ana River has cut off the southern part of the slide which once may have formed a weak dam across the river. This slide must have moved a minimum horizontal distance of about 1,500 feet. That it may have moved almost 3,000 feet is suggested by a large landslide cirque high in the Santa Ana Mountains to the south (fig. 49).

The landsliding is probably contemporaneous with the faulting or slightly later. As landslides override terrace deposits and in several places seem to be mixed with terrace material, they are probably late Pleistocene to Recent in age.

GEOLOGIC HISTORY

The geologic history recorded in the rocks of the Corona area began in Triassic time when most of the area apparently was submerged under the sea. The region then received thick deposits of silt, mudstone or clay, and sandstone and minor amounts of fossiliferous limestone of Late Triassic age. As these strata are much more deformed than the unconformably overlying volcanic rocks of Jurassic (?) age they may well have been folded and mildly metamorphosed and possibly eroded during or at the end of Triassic time.

A great volume of volcanic rock was poured upon a surface of the folded Triassic sedimentary rocks, possibly in Jurassic time. The emplacement of the hypabyssal and plutonic igneous intrusive bodies of the differentiating magma of the great batholith of southern California may have begun in Jurassic time and probably persisted into early Late Cretaceous time. Isotopic dating, however, (Larsen and others, 1958, pp. 35-62) of rocks from the great batholith of southern California indicates that it was emplaced largely or wholly in early Late Cretaceous time. The Triassic rocks and the later volcanic rocks were tightly folded and mildly metamorphosed apparently partly before and probably also during the emplacement of the batholith. Probably during early Late Cretaceous time the area was eroded to a terrain of rather low relief and the batholithic rocks were exposed. Lateral movement along the Elsinore fault zone may have occurred during the Late Cretaceous-early Tertiary time interval.

The area apparently remained a positive land mass during early Late Cretaceous time and received nonmarine sediments. Upper Cretaceous seas then transgressed the area and left a thick deposit of fossiliferous marine strata. Toward the close of the Cretaceous period the area may have again become at least in part a positive land mass and the marine sedimentary rocks were partly eroded away.

The Upper Cretaceous seas may have been the last to cross the region of the present Santa Ana Mountains. The Paleocene, Eocene, and Miocene seas probably did not submerge the central part of the present mountains, but bordered the site of their northern peripheries. Pliocene seas apparently were even more restricted and marginal.

In Paleocene time strata of both marine and nonmarine origin were laid down over a surface of moderate relief. These beds probably represent continuous deposition along the margins of a fluctuating sea under lagoonal and nearshore conditions. Deposition of marine strata marked the Eocene epoch toward or at the close of which the area again became a positive land mass and received continental deposits without apparent interruption from late Eocene to early Miocene time. Probably the area was of moderate relief and near the shoreline of a shallow sea. Subsidence recurred early in the Miocene epoch.

Marine sedimentation was renewed in early Miocene time and must have continued well into Pliocene time. Toward or at the close of the Pliocene epoch the sea retreated as the great orogeny, which initiated the processes that formed the present land features, began. The Tertiary and Cretaceous strata were folded into a great anticlinal arch, at the site of the present Santa Ana Mountains, and a syncline to the northeast. After folding, the relief may have been moderate. A period of major block faulting began in either late Pliocene time or at the end of the Pliocene epoch and has continued, in moderate degree, until the present. Erosion has continuously carved the uplifted mountain blocks into their present complicated forms. Terrace deposits, terraces and broad erosion surfaces, at different elevations, record an irregular rate of uplift.

Summary of major events and salient geologic features.

1. Corona area receiving marine sediments during Triassic time.
2. Folding and mild metamorphism at the close of the Triassic period.
3. Volcanism in Jurassic (?) time.
4. Folding and metamorphism of the volcanic rocks and earlier sedimentary rocks.
5. Jurassic (?) and Cretaceous igneous activity associated with the intrusion of the great batholith of southern California.
6. Erosion to a mature surface, Upper Cretaceous nonmarine sedimentation; subsidence and marine sedimentation in Late Cretaceous time.
7. Possible lateral movement along Elsinore fault zone during Late Cretaceous-early Tertiary time interval.
8. Sites of present Elsinore trough and northern peripheries of Santa Ana Mountains filled with Tertiary sediments. Both marine and nonmarine strata were deposited during different times. Sediments probably overlapped the southwestern Perris Block region.
9. Major folding and block faulting, beginning probably either in late Pliocene or end-Pliocene time, continuing to the present.
10. Tertiary sedimentary rocks rapidly eroded from the Elsinore trough.
11. Development of the present topography and deposition of surficial deposits.

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MINES AND MINERAL DEPOSITS OF THE CORONA SOUTH QUADRANGLE

RIVERSIDE AND ORANGE COUNTIES, CALIFORNIA

By CLIFFTON H. GRAY, JR.
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INTRODUCTION

Mining Districts. Mining districts, at least parts of which are within the Corona South quadrangle, include the Silverado, Santa Rosa, Yorba, and Corona. The designation "Silverado mining district" was early applied to an area generally south of the Corona South quadrangle, but apparently including the part of the quadrangle that lies south of the drainage divide and thus is in Orange County. The settlement of Silverado, in Silverado Canyon, was a mining boom town founded in 1878. It was a center of extensive mining activity until 1881. Most of this activity was south of the area of the present study but that prospectors from Silverado ranged over the area is shown by a number of unidentified prospect pits and adits. The name "Santa Rosa mining district" has been applied to an area in Orange County that also lies mainly south of the Corona South quadrangle, but which also embraces prospects in the southwest part of the quadrangle.

A mining district on the northeast side of the drainage divide has been referred to both as the Yorba and Corona. Yorba, the older term, is the name of the owner of the Spanish land grant which included the present town of Corona and much of the northeastern flank of the Santa Ana Mountains. In recent years, the term Corona mining district has been generally applied to the northeast flank of the Santa Ana Mountains in the southwestern tip of Riverside County.

Acknowledgments. The author wishes to express his appreciation to the property owners and mine operators for their cooperation and helpfulness. Joe Deleo, Jr., Corona, mining contractor and clay supplier, furnished much useful information on the clay deposits. Arthur G. Moore and N. M. Nichols, Gladding, McBean and Company, supplied data concerning recent clay exploration and mining activities, as did Gerritt Poelstra, Tillotson Refractories Company. Data on recent prospecting for glass sand were kindly furnished by Meredith C. Brown. Results of laboratory tests of rock samples from the Sidebotham and Temescal Canyon rock quarries were made available by Mason K. Read, U. S. Army Corps of Engineers. Mrs. Irene J. Ware, who has resided in the area since 1907, provided interesting historical background.

The helpful suggestions of Lauren A. Wright, George B. Cleveland, and Thomas E. Gay, Jr., staff members of the Division of Mines, are gratefully acknowledged.

Mineral Resources. The nonmetallic materials—clay, sand and gravel, glass sand, and broken rock—provide the only commercial minerals currently (1958) produced in the Corona district.

Prospecting for tin, gold, silver, and other metallic minerals was very actively pursued many years ago and has continued on a much smaller scale to the present. Probably the early efforts date from about 1853 when tin was discovered near Cajalco, about 5 miles southeast of Corona (Hanks, 1884, pp. 120-122) and east of the Corona South quadrangle. Tin Mine Canyon, 4 miles southwest of Corona and within the quadrangle, has been prospected for tin, antimony, and other metallic minerals, apparently with little success. The mineralized zones, to which the prospectors were attracted, are in metamorphosed sedimentary rocks of the Triassic Bedford Canyon formation, in Jurassic (?) Santiago Peak volcanic rocks, and in small intrusive bodies associated with the Santiago Peak volcanic rocks.

After the early interest in prospecting for metallic minerals subsided, about 1860, there followed a period of nearly 30 years in which little mining or prospecting was done. Renewed interest in prospecting and mining probably began about 1885 with the discovery of coal, as several prospects were then active about 4 miles southwest of Corona (Goodyear, 1888, p. 505). Since that time the principal interest has been in nonmetallic minerals. By 1910 the emphasis had shifted to clay, which was found to be associated with the coal seams. Gypsum deposits have been explored during the past 50 years, but with relatively little success. Silica sand and broken rock products have become increasingly important since the mid-1940's, and together with clay today form the principal commercial mineral commodities of the area.

Recent prospecting has been aimed mostly at the development of known clay bodies and the discovery of additional clay bodies. Since about 1950 clay shale deposits, of both Paleocene and Upper Cretaceous age, have been extensively developed in the area southwest of Corona, and the mined products are being utilized in the manufacture of common clay products. These clay shales were first mined about 1910. The discovery, in 1954, of a large deposit of Paleocene clay in the lower Bedford Canyon area, by Gladding, McBean and Company, marked the most important mining development that had occurred in the Corona area for many years. Indeed, this was one of the principal discoveries in the history of the clay industry in California.

In May 1957, a new quarry for riprap and facing rock was opened along the northeast margin of Temescal Wash. This may prove to be a significant source of material for the construction industry.

Exploration for petroleum along the northeastern margin of the Santa Ana Mountains is of continuing local interest but has led to very little production. One dry hole was drilled during 1956 and several operators were holding active oil and gas leases in 1958.

Uranium prospecting, which was especially intensive in the mid-1950's, extended into the Santa Ana Mountains. A number of claims were staked in the Corona South quadrangle by some of the many "week-end" prospectors that tried their luck. In 1958 most claims remained undeveloped and none had been productive.

The Corona area has furnished a significant part of the mineral production of Riverside County. In the future the nonmetallic deposits of the Corona area promise to be even more important, both to the development of southwestern Riverside County, in particular, and to the building and industrial mineral industries of southern California in general.

The principal mining properties in the Corona South quadrangle are described below in alphabetical order. The first section is devoted to metallic minerals and the second to nonmetallic minerals. A third section deals briefly with ground water, and a fourth with petroleum exploration activities. Where locations are given in miles from Corona, the distance is measured from the center of town (6th and Main Streets). A tabulation of all known mining properties is included at the end of the report.

METALS

Gold

Gold-bearing quartz veins are reported (Tucker, 1925) to have been discovered in the Corona South quadrangle along Ladd Canyon in 1896. Early day prospectors searched for the precious metal, but so far as known, no noteworthy lode or placer discoveries were made. Gold production from this area must have been small, if any, and none is recorded.

Williams (Ophir ?) Mine. Location: secs. 4 and 9 (?), T. 5 S., R. 7 W., S.B.M. about one airline mile north of Silverado Post Office in Ladd Canyon, in the vicinity of the junction with the West Fork of Ladd Canyon. Ownership: Undetermined.

The Williams mine area is said to have been first located in 1896. By 1925 the property comprised the Williams group of four lode claims owned by J. Goodby, Los Angeles. This area was apparently also covered by the Ophir group of six lode claims which were held by Frank Requa and L. O. Hall in the 1930's. The early prospecting was for gold and later owners prospected also for silver, lead, and zinc. There is no known production.

Tucker (1925, pp. 59-60) described the Williams vein as a gold-bearing quartz vein, 1 to 2 feet in width, on the contact of slate and porphyry. The vein was reported to contain free milling gold and a small percentage of pyrite, to be exposed on the surface for 1,500 feet, to strike due north, and to dip 60° east. The geologic setting, as described by Tucker, closely resembles the geology of the southwest corner of sec. 4, T. 5 S., R. 7 W., S.B.M. where Triassic Bedford Canyon formation metasedimentary rocks are in contact with slightly metamorphosed porphyritic andesites of the Jurassic (?) Santiago Peak volcanics. However, the quartz vein was not found during the present study.

The property was reported by Tucker (1925, pp. 59-60) to be developed by a crosscut adit driven 150 feet west. At the time of Mr. Tucker's visit in 1925, the property was idle and the workings caved. In June 1956, no identifiable trace of this mine remained and the area had a dense brush covering. An old cabin remains in the vicinity. Several debris piles and one short, caved adit on the south side of Ladd Canyon in the northwest corner of sec. 9 may mark former mine workings.

Lead-Silver-Zinc

Prospecting for lead, silver, and zinc along Silverado Canyon on the west flank of the Santa Ana Mountains reached a peak about 1880 when several adits and prospect pits were opened. Apparently none in the Corona South quadrangle was ever developed into a mine. Later prospecting on the east flank of the mountains resulted in the discovery of the Corona lead-zinc mine in Manning Canyon. Some of the mineralized zones that were prospected are in intrusive dikes and plugs related to the Jurassic (?) Santiago Peak volcanics. Others are in altered metasedimentary rocks of the Triassic Bedford Canyon formation. Records of production, if any, were not found. All lead-silver-zinc prospects have long been idle.

Corona Lead-Zinc Mine. Location: SE¼ sec. 14, T. 4 S., R. 7 W., S.B.M., about 4 miles south of Corona on a steep ridge along the west side of Manning Canyon, midway between Eagle and Main Street (Gypsum) Canyons. Ownership: Robert A. Mattey, Jr., 11359 Biona Drive, Los Angeles 66, California, formerly held five lode claims by location: Wild Oak Nos. 1-5. Part of the area covered by these claims is probably included in Eagle Group No. 3 placer located in 1953 by T. A. Fraser, 718 Howard Street, Corona, California.

The Corona lead-zinc mine was located by Joe Smith, Temecula, California, and Fred Spiess, Corona, California, probably in the early 1940's. In 1943-45 it was under lease and option to Victor Mishelle, Corona Lead-Zinc Company, Malibu Beach, California, but was idle when visited by Tucker and Sampson in 1945 (Tucker and Sampson, 1945, p. 147). The claims were abandoned and relocated by Robert A. Mattey, Sr., about 1947. He later deeded the claims to R. A. Mattey, Jr., who subsequently relocated the group about 1948 and did some development work for several years. This included building and improving roads, developing the water supply, removing a small tonnage of rock from the crosscut adit, and repairs to the mill, which, however, was never operated by Mr. Mattey. In 1953 the writer found the principal adit locked, the open cuts slumped, and the entire area covered with dense brush. The most recent known activity was in 1953 when ten tons of clay shale was mined from a small open cut on the east end of the property.

According to Tucker and Sampson (1945, p. 147) the Corona lead-zinc mine explores a vein that contains oxidized lead-zinc and occurs in marine metasedimentary rocks. The mineralized areas occur along fracture zones in a small pod of quartzite, gray hornfels, and metagraywacke of the Triassic Bedford Canyon formation. The metamorphic rocks are engulfed in hornblende andesite of the Jurassic (?) Santiago Peak volcanics. Most of the lead-zinc is in a single discontinuous calcite-quartz vein exposed high on the steep west side of Manning Canyon. The vein material is mostly limonite-stained white to brown calcite with minor amounts of vein quartz showing sparse black manganese dendrite. The vein fills a fracture zone which strikes northeast and dips 45° northwest. The vein ranges from 2 to 6 feet in width, but the mineralized zone extends over as much as 15 feet and the metasedimentary country rock carries pyrite and pyrite altered to limonite. When the writer visited the property in 1953 little vein material was encountered and no ore minerals were observed.

Development has been by open cuts and adits. Tucker and Sampson (1945, p. 147) described the development thus: main working was an open cut driven northeast for 360 feet and which explored the principal fracture zone high on the ridge west of Manning Canyon. Three hundred feet below the open cut and at the floor of Manning Canyon on its west side a crosscut adit, 92 feet long in 1945, was being driven N. 15° W. to intersect the vein exposed by the open cut above. This crosscut apparently did not cut the vein, although the rock in the face carried pyrite. Farther up Manning Canyon, about 300 feet west of the crosscut adit, there is a small open cut and two short adits are driven on a vein parallel to the principal mineralized zone exposed on the ridge above.

A mill with capacity of $1\frac{1}{2}$ tons per hour was erected in Manning Canyon in the early 1940's. Milling equipment consisted of jaw crusher, roller mill, screens, and two concentration tables; middling product from tables went to a Lamley jig, tailings to waste. Ore mined from the principal open cut 300 feet above the mill was moved to the mill by gravity by means of a wooden chute. This ore was said to be antimonial lead ore and reported to assay 10 percent lead, 14 percent antimony, and 40 ounces of silver per ton (Tucker and Sampson, 1945, p. 147). The mill is said to have been in operation about 1943, but no record of production was found. In 1956 the mill building, minus much of the equipment, remained on the property which was idle. Only annual assessment work appears to have been done for several years.

The eastern part of these claims apparently included clays and clay shales of the Paleocene Silverado formation. Several small open cuts along the west side of Manning Canyon explore the shales.

Tungsten

Small amounts of scheelite (?) are reported (Hilton, 1950, p. 80) to have been found in a few fractures and veins in the Temescal Wash quartz latite porphyry at the Temescal quarry of the Minnesota Mining and Manufacturing Company. This occurrence was not verified by the writer.

Uranium

In recent years radioactive minerals have been sought in the northern Santa Ana Mountains by many "weekend" prospectors. Numerous claims were located within the Corona South quadrangle, particularly along Tin Mine and Silverado Canyons where volcanic and metamorphic rocks are exposed. None has been developed other than by shallow prospect pits.

The writer made a reconnaissance of this area by following truck trails with a Jeep carrying an Engineers Model SC-10 combination scintillation and geiger counter. Nothing above a low background count was observed.

NONMETALLIC MINERALS

Clay and Clay Products Manufacturing Plants

History of Development

The Corona South quadrangle contains part of the oldest and most productive clay district of southern California. The first operation, which was opened as early as 1890, was the McKnight mine. This property, together with a number of smaller deposits extending along the northeast flank of the Santa Ana Mountains between Wardlow Wash and Joseph Canyon, was active until about the middle 1930's and furnished a considerable tonnage of red-burning clay and flint-fire clay.

During the early period of operation several tile manufacturing plants west of Corona were supplied from deposits in the Corona South quadrangle. The Corona Pressed Brick and Terra Cotta Company, which between 1905 and 1910 operated a plant near the railroad half a mile west of Corona, produced high-grade pressed building brick (Aubury, 1906, p. 223). Later the plant was operated by the Pacific Sewer Pipe Company, but was dismantled before 1916 (Merrill, 1919, p. 570). About the same period the Pacific Clay Manufacturing Company operated a plant (fig. 1) near the railroad one mile west of Corona. This company was succeeded by the

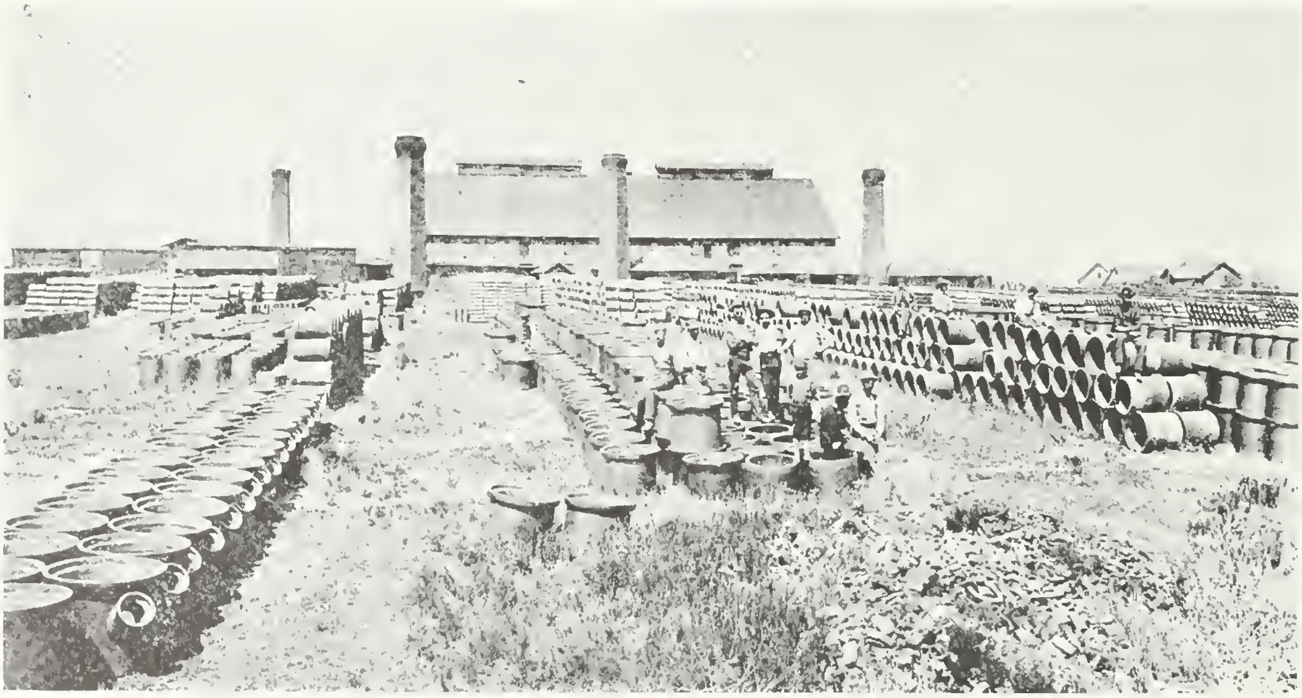


FIGURE 1. Pacific Clay Manufacturing Company plant, Corona, about 1902. This plant, destroyed by fire about 1920, occupied the site of the present Jordan Tile Manufacturing Company. Photograph from a brochure, *Corona, California, The Queen Colony, Illustrated*, published by the Corona Publishing Company, 1902. *Courtesy of Mr. and Mrs. Howard S. Ware, Corona, California.*

Pacific Sewer Pipe Company, which later became the present Pacific Clay Products organization. The plant was active as early as 1902 and was still active in 1919 (Boalich and others, 1920, p. 90) but was destroyed by fire several years later. For several years beginning in 1905 refractory clay from the McKnight mine was used in these plants to make fire brick (Aubury 1906, p. 224). In the early 1900's, clay from the McVicar pit (now part of Sky Ranch Clay Company property) was shipped to Los Angeles and used by the California Clay Manufacturing Company (Aubury 1906, p. 223), which later became the Los Angeles Brick Company and is now the Los Angeles Brick and Clay Products Company.

For many years at a plant at the settlement of Prado, west of Corona, hand-made roofing tile and Mexican pottery were manufactured from clays supplied from the Corona area. This plant which was operated at different times by the Prado Tile Company, La Olla Tile Company, and the Casa Blanco Tile Company, was closed about 1940 when the Prado flood control project acquired the former site of Prado.

Clay shales from the Corona South quadrangle were first mined and used in the manufacture of common clay products by the Corona Pressed Brick and Terra Cotta Company at their Corona plant during 1905-10. This material also was mined and used at the Colton cement plant during this same period (personal communication, Mrs. Mary Mattey). Each year since about 1950 a few thousand tons of Paleocene and Upper Cretaceous clay stones and fissile shales, principally from the Mabey Canyon and Wardlow Wash area along the west edge of the quadrangle, have been quarried and used as a source of red-burning clay for the manufacture of common clay products. Two plants in the Corona area are currently (1958) operating: Tillotson Refractories Company, 1150 West 6th Street, Corona, and Jordan Tile Company, 909 Railroad Street, Corona. These clay shales also have been used since about 1951 by Mission Clay Products Corporation, Olive, the Atlas Sewer Pipe Company, Whittier, and are supplied to a number of small pottery and brick manufacturing plants in southern California.

Since 1948 the Liston Brick Company in lower Bedford Wash has been using small amounts of Miocene diatomaceous shale and Quaternary alluvium in the manufacture of red brick.

Mining of Paleocene clay in the Corona area was carried on intermittently and on a small scale from the closing of the McKnight mine in the late 1930's until 1954, when large reserves of Paleocene clay were discovered and developed in lower Bedford Canyon, near its intersection with Temescal Wash. A quarry was opened there in 1955 and is mined periodically. In July 1956 Gladding, McBean and Company began construction of a large clay products manufacturing plant at that site; the plant was placed in operation in early 1958.

Geology of Clay Deposits

The Alberhill-Corona clay district, which includes the above-mentioned deposits in the Corona South quadrangle, is the principal clay-producing area in southern California. Although production from the Corona region has been small in recent years, it will be of major importance when the newly discovered deposits in Bedford Canyon are put into full production.

The clay deposits, which are included in the Paleocene Silverado formation (geologic text, pp. 23-29), crop out discontinuously in an irregular, rather narrow, horseshoe-shaped belt, the ends of which point southeast. The deposits extend northwest from Elsinore to Corona, around the northwest tip of the Santa Ana Mountains and thence southeastward on the west flank of the mountains across Trabuco Canyon to the Tierra Colorado clay district in southeastern Orange County (figure 2). The clays in the district show two types of origin—residual and sedimentary. However, most of the clay of both origins probably was originally derived from weathered surfaces of Jurassic (?) or Cretaceous hypabyssal intrusive rocks. Less abundant are clays that have weathered from Triassic argillites and slates. Elsewhere in the Santa Ana Mountains Cretaceous shales may have been a source of clay.

In the Corona South quadrangle small lenses of sedimentary clay crop out in a discontinuous belt of Paleocene sandstone, shale and conglomerate averaging about half a mile in width and extending from Brown Canyon northwest across most of the quadrangle. Probably large areas, masked by younger sedimentary rocks, are underlain by this formation.

Residual Clays. Residual clays have developed in place by subaerial chemical weathering of aluminum-rich rocks which, in the Alberhill region, include: (1) quartz latite porphyry, (2) quartz latite volcanic breccia, (3) Santiago Peak volcanics, latite to andesite, (4) mixed gabbro-diorite, and (5) Bedford Canyon formation slates. In the Corona area the source materials are quartz diorite and argillite or slate. The textures of the igneous rocks are well preserved in the lower parts of the residual sequences, which grade down into unaltered rock. Outlines of feldspar phenocrysts and hexagonal quartz grains and slaty cleavage are remnant structures that indicate the residual clay was derived from hypabyssal igneous rocks and slate, respectively. In all exposures the igneous source rocks are those rich in plagioclase feldspar.

Residual clays have been noted in only two places in the Corona South quadrangle and in each occurrence the clay is derived from a distinct rock type—metasedimentary rock at one and intrusive rock at the other. In a small exposure south of Cajalco Road and along the east side of the railroad (No. 2, plate 1) a layer of bright brick-red clays about 30 feet thick grades successively downward into gray and greenish-buff clay and unaltered argillites of the Triassic Bedford Canyon formation. These clays are overlain unconformably by a 5-foot thickness of sedimentary white sands of the Paleocene Silverado formation. This deposit has been idle for many years and appears to be of very limited extent. The second and more extensive residual deposit was exposed by excavations made in lower Bedford Canyon in 1955. Here brick-red and red and gray mottled residual clay ranging in thickness from 5 to 20 feet with a thin, but as much as 4 feet thick, discontinuous pisolitic zone at the top is developed on a weathered surface of hornblende quartz diorite. Fracture and shear zones in the basement rocks extend into the residual clay zone but do not appear

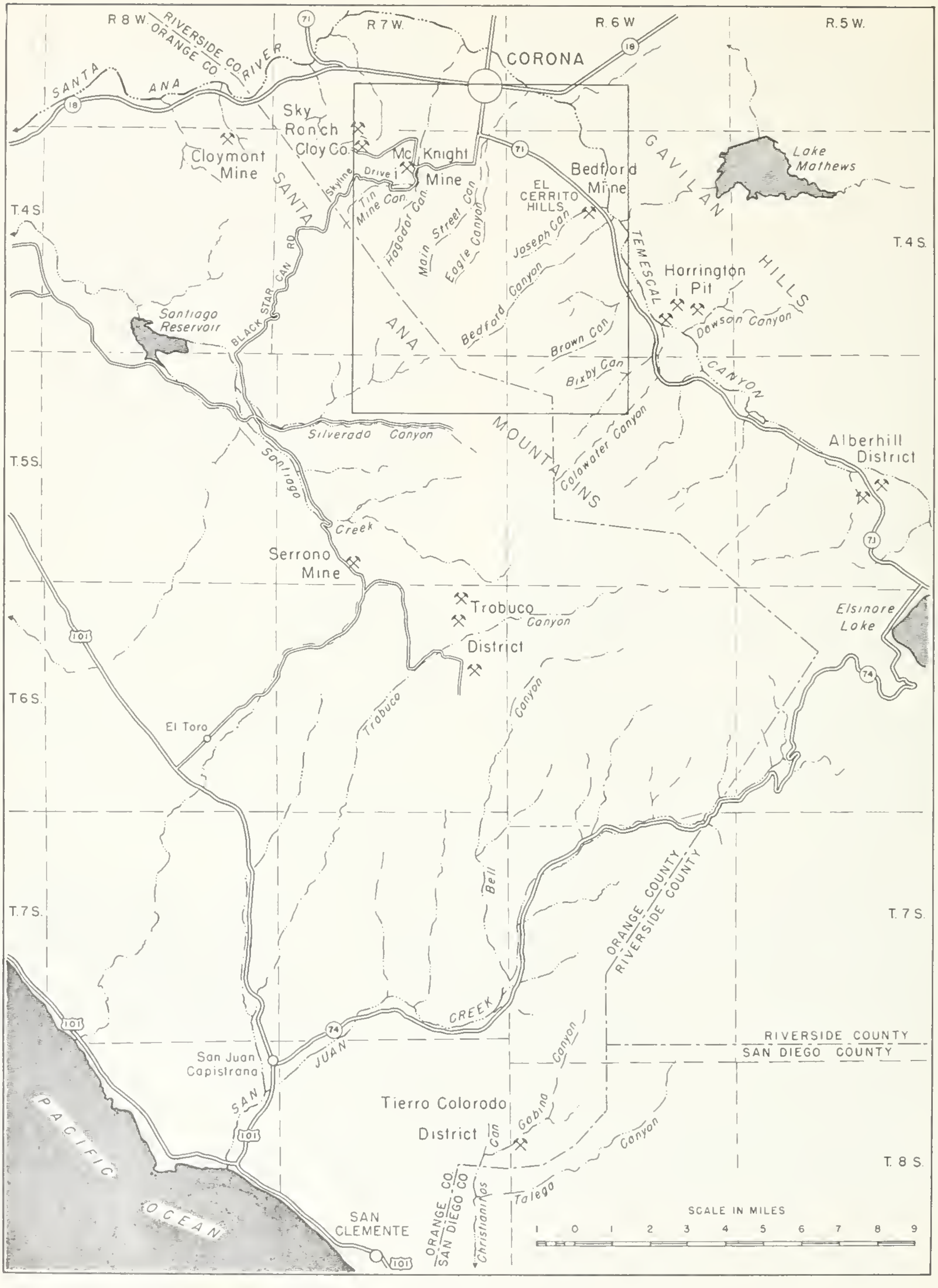


FIGURE 2. Sketch map showing location of Corona South quadrangle and principal Paleocene clay mines and clay districts in the northern Santa Ana Mountains, Riverside and Orange Counties.

to have cut the overlying sedimentary sequence. The irregular erosion surface at the top of the residual clay at the Bedford Canyon locality is overlain, in order, by: buff sand; red mottled transported clay with a pisolitic zone at the top; buff to white coarse arkose; stream channel material; and older alluvium.

The residual clay was derived during a period of intense weathering before deposition of the Paleocene Silverado formation. Recent drilling (1956-57) has shown that a sequence similar to that in the Bedford Canyon locality underlies a large area in lower Bedford and Joseph Canyons. Drill holes in other areas, southeast toward Elsinore, are said to have penetrated similar sequences.

Sedimentary Clays. The sedimentary clays in the Corona area differ from place to place but are of four general types: (1) buff to red and yellow iron-stained clay shale; (2) white to red and red mottled red-burning clay with good plasticity (locally called "red plastic" or "potters" clay); (3) brownish-red to yellowish-green pisolitic clay (locally called "bone-clay" or "bauxite"); and (4) dark gray to black, fine-grained, dense kaolinite with a conchoidal fracture and a wide range in sand content (locally called "flint fire clay", or "fire clay"). These types, especially the gray kaolinite, are commonly associated with lignite and are found near the base of the Silverado formation. The lignite contains local lenses of pisolitic clay.

In the Corona area, the sedimentary clay-bearing formation has been so deformed by folding and faulting that although individual beds occur similar to those found to the southeast at Alberhill, no complete sections were observed in this area. Exposed at Alberhill is the following typical section, about 46 feet thick, of sedimentary clay, which overlies residual clay.

(top)
Red and white mottled claystone
Yellow and gray mottled claystone
Pisolitic clay, brownish red or yellowish green in color, and composed of round, concentric pisolites ("bone clay")
Red and gray mottled claystone
Banded claystone, gray and yellow-buff colored
Clayey sandstone, sand grains mostly quartz
Gray claystone, kaolinite ("fire clay")
Carbonaceous claystone, commonly associated with lignite
(bottom)

The foregoing units are all found in the Corona area and apparently in the same order of deposition, but only in isolated patches. Probably the most complete section similar to that found at Alberhill is at the McKnight mine, but the workings that exposed the clay are now inaccessible.

The clay beds which crop out in the vicinity of the McKnight mine and in isolated patches for about 6 miles to the southeast are intercalated with shales, buff to white arkosic sandstones, and conglomerates of the Paleocene Silverado formation (see geologic text, pp. 23-29). The clays grade gradually downward into the sandstones and conglomerates which are faulted against the underlying basement rocks. The sandstones are generally green or buff but near the top grade into dark colored shales of gray and reddish-brown. In places the underlying sandstone is reddish-green, very fine-grained and platy and carries such abundant black to greenish-black mica (biotite and muscovite) and pearly gray anauxite that it has a schistose appearance. The clay beds generally are overlain by clay shales which are almost everywhere stained red, pink or yellow by iron oxide. At the Bedford Canyon locality and at a few places along the northeast margin of the Santa Ana Mountains, the clays are overlain by buff and white sandstone. Two principal typical varieties of clay are found at the McKnight mine, although minor amounts of all eight of the varieties listed from Alberhill are also found. An upper bed of red mottled clay is as much as 60 feet thick and contains lenses of pisolitic clay. A lower bed consists of gray or blackish-gray fire clay reported to reach 30 feet in thickness. Some of these lower clays are reported to be highly refractory but to have a low fired strength (Dietrich, 1928, p. 277). However, none are now exposed. These clays by today's standards probably would be classed as low refractory clays.

The sedimentary clays are best exposed at present in new excavations in lower Bedford Canyon. However, the section is not complete as no fire clay or lignite is present. Residual clays are overlain by 5 to 15 feet of buff sand followed by 10 to 15 feet of red mottled sedimentary clay with a thin 1- to 5-foot-thick zone of bleached pisolitic clay at the top. The upper surface of the clay-bearing zone is irregular and overlain by coarse, white, anauxite-bearing arkose. A spectrographic semiquantitative analysis of the pisolitic zone indicated major constituents of aluminum, silicon and iron with trace elements including titanium, magnesium, manganese, boron, gallium, vanadium, barium, chromium, and silver. X-ray diffraction analysis of this material indicated both the red clay matrix and the oolitic inclusions (pisolites) to be kaolinite (from unpublished data collected by the Division of Mines).

Paleocene Silverado formation and Upper Cretaceous Ladd formation clay shales have been utilized in recent years as a constituent for the manufacture of common clay products. Large reserves of these clay shales are indicated as they crop out over much of an area of about one square mile in the northwest corner of the quadrangle north of Mabey Canyon and west of Wardlow Wash.

Origin of the Sedimentary Clays. The Paleocene clays, as already stated, apparently were produced during a period of deep weathering during the emergence that followed Cretaceous time. The weathered surface was then partly eroded and the clay-bearing Silverado formation was deposited unconformably on rocks ranging in age from Triassic to Cretaceous, or on the weathered materials derived from them. The Paleocene beds probably were laid down as a continuous deposit over the area of the present northern Santa Ana Mountains. These beds were later much deformed by folding and faulting.

The Paleocene sediments are related not only to the source rocks in the nearby land areas but to the topography of the old surface. It is postulated that coarse sands and cobble-to-boulder conglomerates were deposited where the adjacent land was high; sands and clays were deposited where it was low. The high-grade clays were deposited only where favorable conditions of sedimentation existed as in quiet bodies of water adjacent to low lands. The high-grade fire clays were probably deposited in small lagoons or bogs, with concurrent deposition of coarser material at their margins and with occasional coarse beds intercalated with the clays. The sedimentary red mottled clays commonly are similar to nearby or underlying residual clay. These sedimentary clays probably moved only a short distance from nearby highs during Paleocene submergence. The red mottled clays are more widespread than the gray fire clays as they did not require the special conditions of deposition outlined above.

The sedimentary clays represent the lowermost part of the Paleocene sedimentary sequence and are nonmarine or lagoonal. The alumina-rich clay is associated with lignite beds and other carbonaceous material. In many places a fossil oyster reef occurs a short distance above the clays and a significant Paleocene marine fauna is found above the oyster reef. Therefore the conditions of depositions during early Paleocene time in the Corona area were: nonmarine or lagoonal deposition of clays; brackish water conditions following clay deposition during a transition period; and finally marine deposition of the sedimentary sequence overlying the clays.

Alumina-Rich Clays. The Silverado formation of the Corona district contains considerable quantities of alumina-rich clays, and small amounts of bauxitic clay and high-silica bauxite. These clays are the fire clay and pisolitic zones of both the previously described residual and sedimentary units.

During World War II these clays attracted much interest as a possible source of aluminum as new sources of supply were believed to be imperative. The U. S. Geological Survey made several geologic investigations of the Alberhill-Corona-Tierra Colorado clay region; sev-

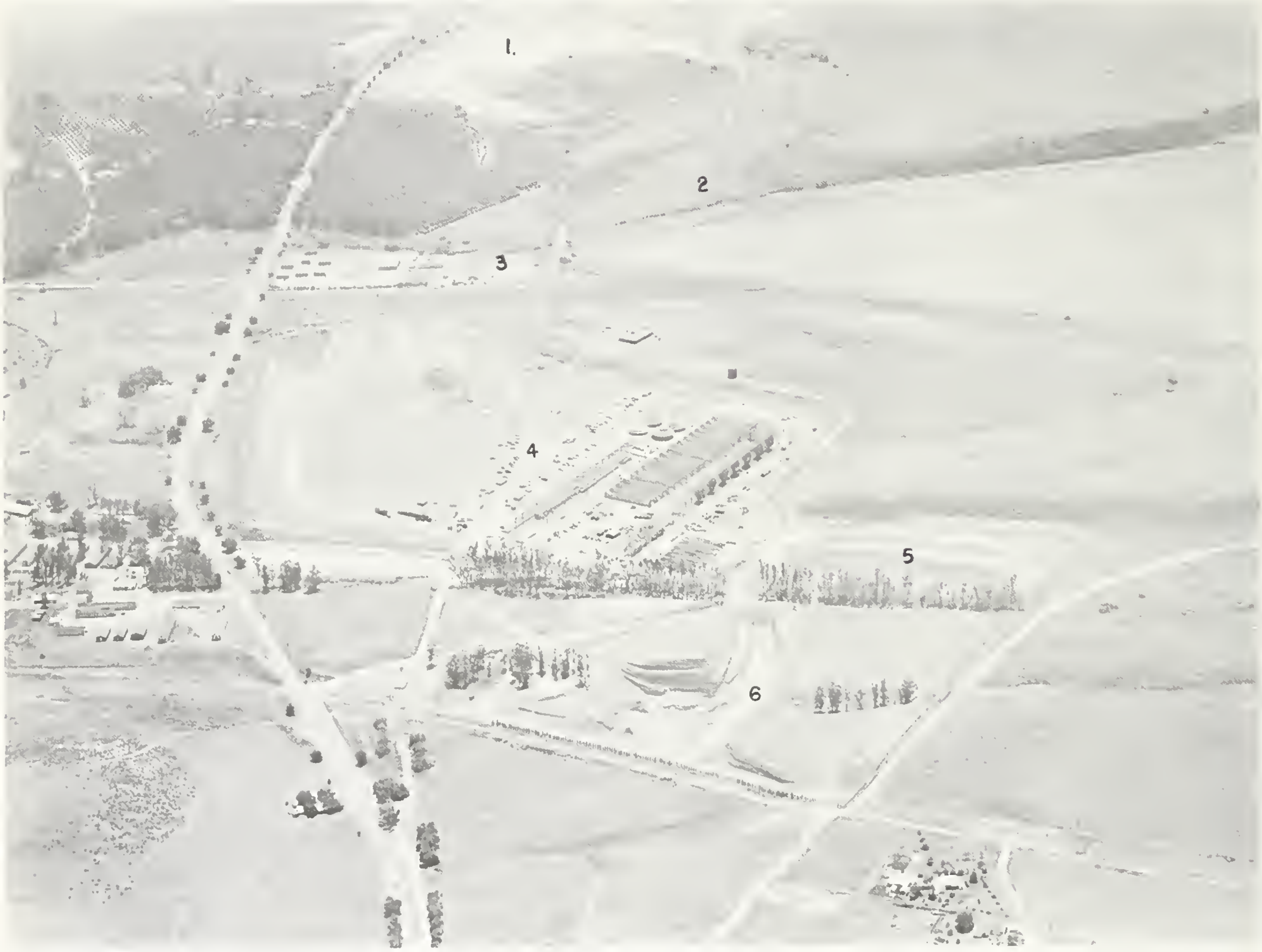


Figure 3. Oblique aerial view of lower Bedford Wash (center) and Temescal Wash (extreme left) in the Corona-Elsinore trough showing principal mineral producing operations in the east central portion of the Corona South quadrangle, June 1957, (1) Sand quarry and processing plant of Owens-Illinois Glass Co. (Corona silica sand deposit), (2) Coronita Ranch sand deposit (undeveloped), (3) Liston Brick Co., (4) Corona (Bedford Canyon) vitrified clay pipe manufacturing plant (under construction, 1957), Gladding, McBean and Co., (5) clay stockpiles, Gladding, McBean and Co., (6) Bedford Canyon clay mine, Gladding, McBean and Co. Glass sand and clay are produced from the Paleocene Silverado formation. Alluvium and terrace deposits cover much of the geology and there are only a few exposures outside of quarry areas. Observer faces southeast. *Photograph by Pictorial Crafts, Incorporated, San Bernardino, California, courtesy of Gladding, McBean and Company, Los Angeles, California.*

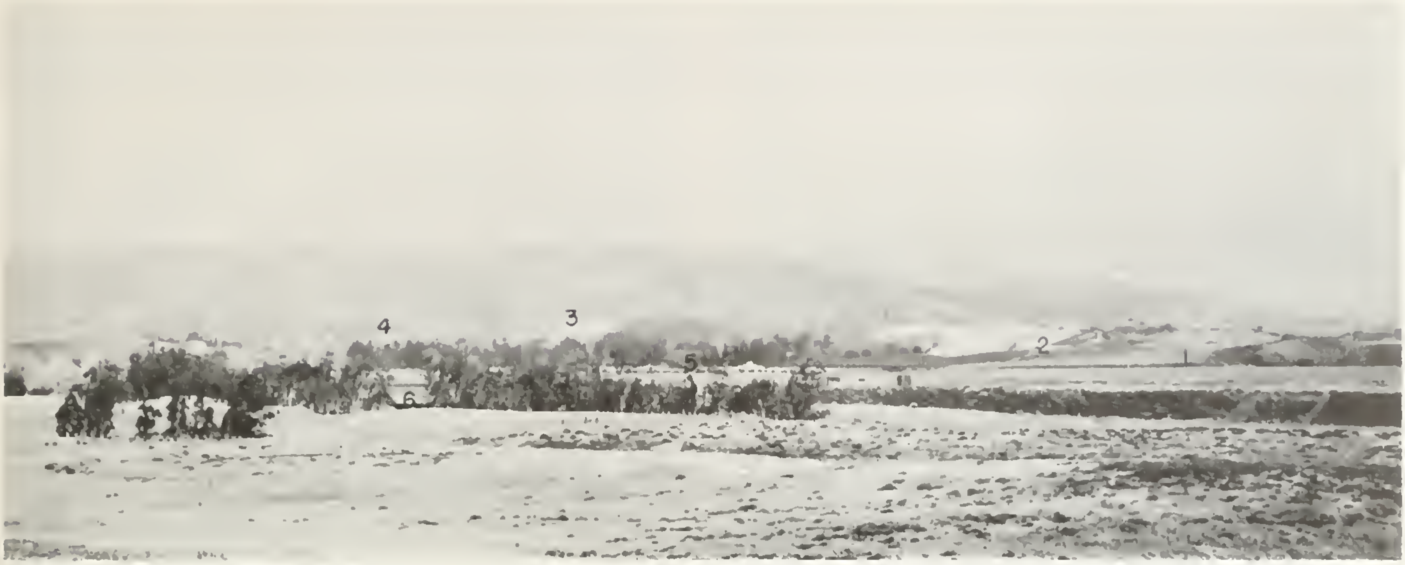


Figure 4. Mineral deposits and mineral processing plants in Corona-Elsinore trough near Bedford Wash, (1) Coronita Ranch sand deposit, (2) Corona silica sand deposit (Owens-Illinois Glass Co.), (3) Blarneystone rock quarry (metavolcanic rock used for riprap, quarry just east of Corona South quadrangle), (4) Cajalco clay pit, (5) Liston Brick Company, (6) Corona plant, Gladding, McBean and Company, quarry at left behind trees. Observer faces southeast.

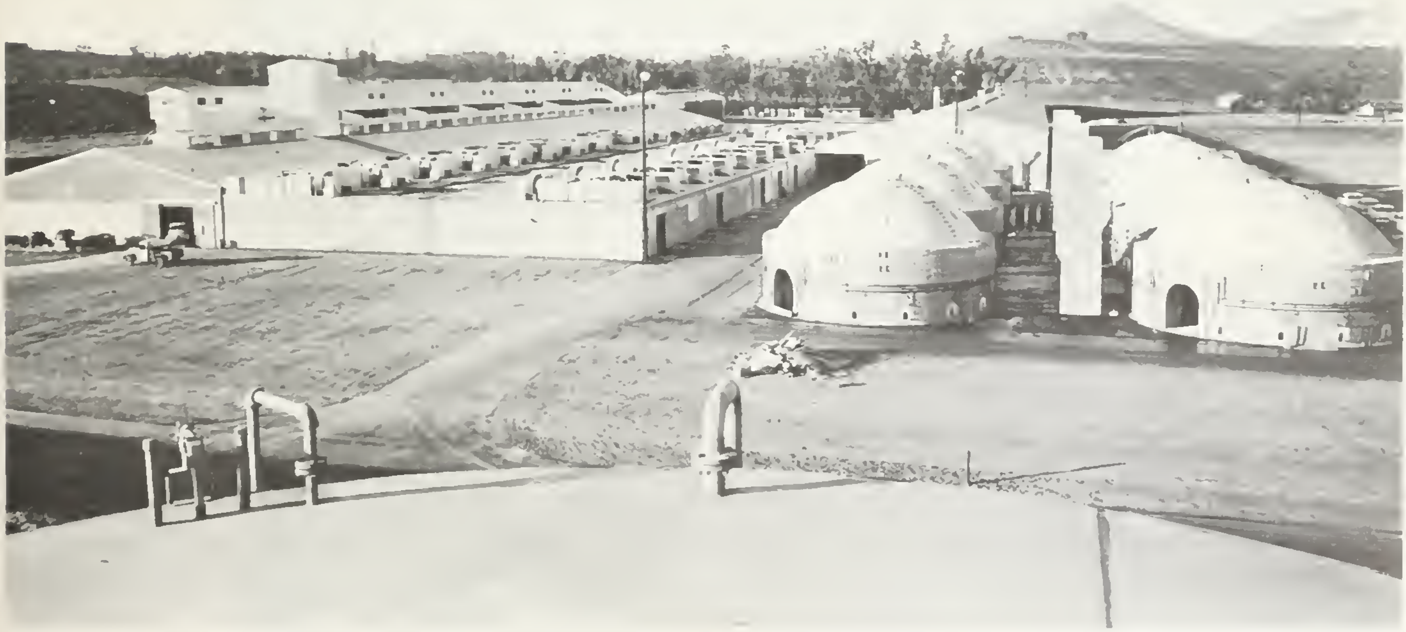
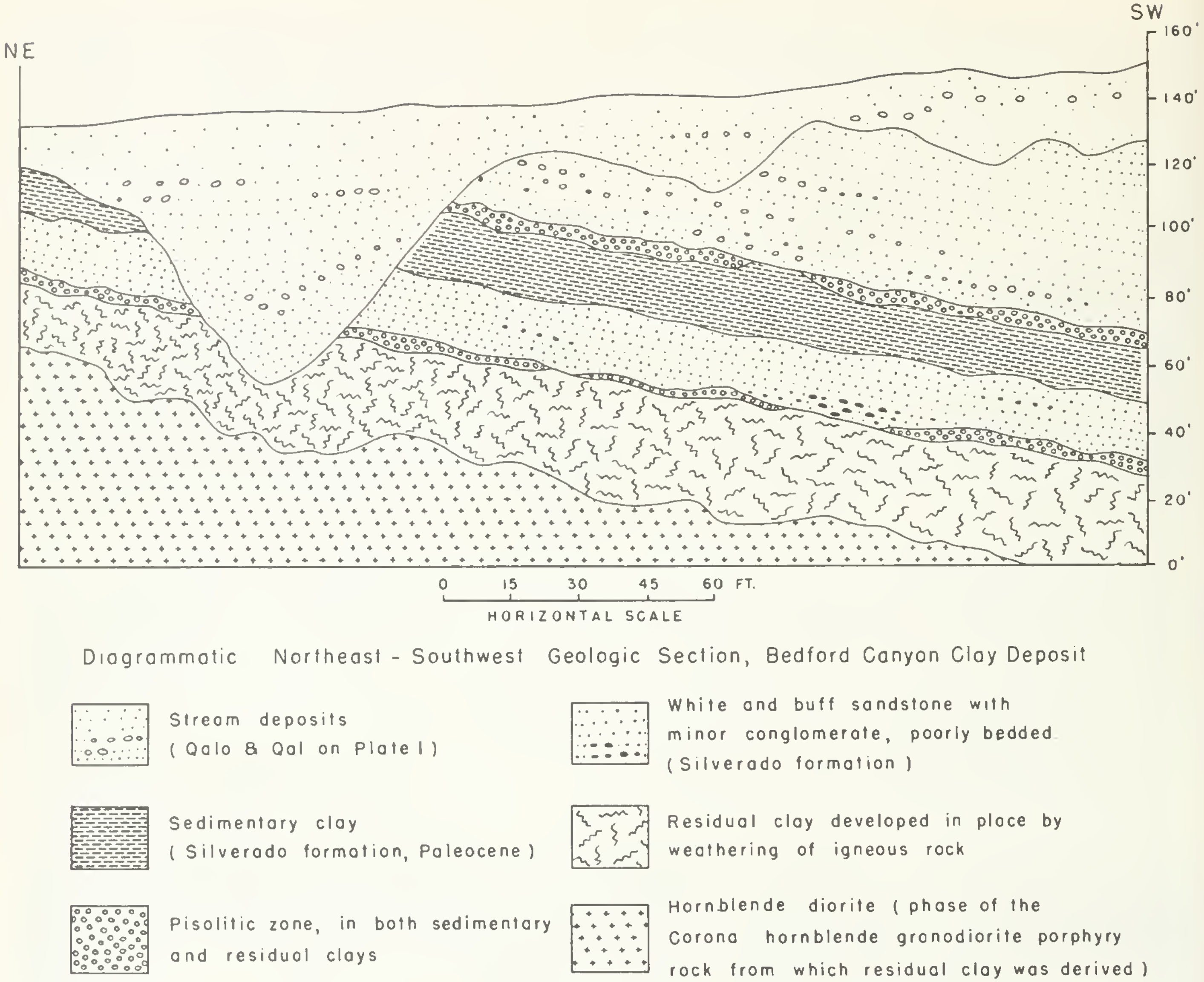


Figure 5. Gladding, McBean and Company's Corona vitrified clay pipe manufacturing plant in lower Bedford Wash. The clay (Paleocene Silverado formation) is mined from an open pit behind trees at left and stored in stockpiles at left. The structures from left to right are—tower and vertical press building and conveyor shed, auger press building, drying buildings (low structures to the left of center) and periodic "beehive" kilns. Observer faces northwest. *Photograph by David P. Shelhamer, Los Angeles, California, December 1957, courtesy of Gladding, McBean and Company, Los Angeles, California.*


NE
SW
160'
140'
120'
100'
80'
60'
40'
20'
0'
0
15
30
45
60 FT.
HORIZONTAL SCALE
Stream deposits (Qalo & Qal on Plate I)
Sedimentary clay (Silverado formation, Paleocene)
Pisolitic zone, in both sedimentary and residual clays
White and buff sandstone with minor conglomerate, poorly bedded (Silverado formation)
Residual clay developed in place by weathering of igneous rock
Hornblende diorite (phase of the Corona hornblende granodiorite porphyry rock from which residual clay was derived)

Diagrammatic Northeast - Southwest Geologic Section, Bedford Canyon Clay Deposit

Figure 6

eral reports were placed on open file and a general study by Stauffer (1946) was published. The Aluminum Company of America briefly investigated the Alberhill deposits and the Kaiser Steel Corporation examined one area (Middlesworth Clay deposit) as a possible source of alumina for steel manufacture (Draper, 1944). These studies failed to indicate sufficient reserves of alumina-rich clay that could be mined as aluminum ore.

Prospecting for Clays

Prospecting for new clay bodies would be greatly hindered by the deep cover of alluvial fan material and terrace gravels and by the lack of knowledge concerning the degree and nature of the deformation of the hidden clay-bearing zones. A knowledge of the pre-Silverado surface would be of great benefit to prospecting, but, unfortunately, indications of the old topography are not clearly evident.

The easily located clay beds were discovered years ago and those that proved valuable were mined. Any remaining undiscovered deposits are probably too deeply buried for effective prospecting by surface methods and therefore future prospecting should be carried on by detailed geologic studies and core drilling of favorable areas. This method recently resulted in the above-mentioned discovery in lower Bedford Canyon.

In general, the more promising areas for prospecting are those away from the Santa Ana Mountains and on the northeast side of the Elsinore-Chino fault zone. Less promising are the areas closer to the mountains and within the fault zone. The clay-bearing beds probably do occur in these latter areas, but the overburden there is probably too thick for open-pit mining. Paleocene sedimentary beds exposed at the surface between the Elsinore and Chino faults furnished the limited clay mining operations carried on in the Corona district years ago. However, based on field observations, it appears there is only a remote possibility of finding additional reserves, in this area, suitable for large-scale mining.

As previously stated, the known deposits of residual clay are developed on plagioclase-rich igneous rocks, slates, and argillites; thus the alluvium-covered margins of such basement rock bodies appear to be the best places for prospecting. The residual clays in lower Bedford Canyon are developed on hornblende quartz diorite, a phase of the Corona hornblende granodiorite porphyry. This porphyry, whose margins are in part covered with alluvium, crops out in several irregular bodies over an area of about 2 square miles in the northeastern part of the Corona South quadrangle. These areas could well merit further attention by the prospector.

Prospecting and exploration of Paleocene and Cretaceous clay shales have been and should continue to be effectively carried out by surface trenching with bulldozers. Supplemental core drilling of promising areas will prove valuable for depth determination as these shale bodies are ordinarily lensing, are commonly cut by faults, and may pinch out at depth.

Bedford Canyon (Corona) Clay Deposit. Location: N½ sec. 16, T. 4 S., R. 6 W., S.B.M., on the west side of Temescal Wash, on State Highway 71 about 5 road miles southeast of Corona. Ownership: Gladding, McBean and Company, 2901 Los Feliz Boulevard, Los Angeles 39 (P.O. Box 578, Corona), own approximately 160 acres in an irregular shape in the N½ sec. 16. This property was formerly private ranch land. Arthur G. Moore, Corona, is assistant superintendent and resident engineer of the Corona plant and N. M. Nichols is division geologist.

The Bedford Canyon clay deposit, as previously stated, was discovered in August 1954 by geologists of Gladding, McBean and Company who were engaged in an intensive exploration program. The clay was not exposed as the entire area was covered with alluvium. However, Stauffer (1946, map station 32) mentioned an old test pit, at the east edge of El Cerrito Hills along the northwest margin of Bedford Canyon, which at a depth of about 20 feet penetrated residual, red, mottled clays on the weathered surface below the Silverado formation. In 1950 the writer found little trace of this pit. The Bedford Canyon area was considered likely to contain a large clay body as it was assumed to be underlain by the Silverado formation. Indeed, Paleocene clay deposits were known to crop out nearby and to have been mined, on a small scale. The property was taken under an option and initial exploration was entirely by core drilling. The first core hole is reported to have penetrated 40 feet of overburden and then 100 feet of red clay. Construction of a plant (figs. 3, 4, 5) for the manufacture of red-burning clay products began in July 1956, and it was placed in operation on January 1, 1958.

It is noteworthy that this discovery was made with modern methods of prospecting which included regional geological studies and the core drilling of areas indicated to be favorable. This discovery may be the most important clay find made in California since the early 1900's.

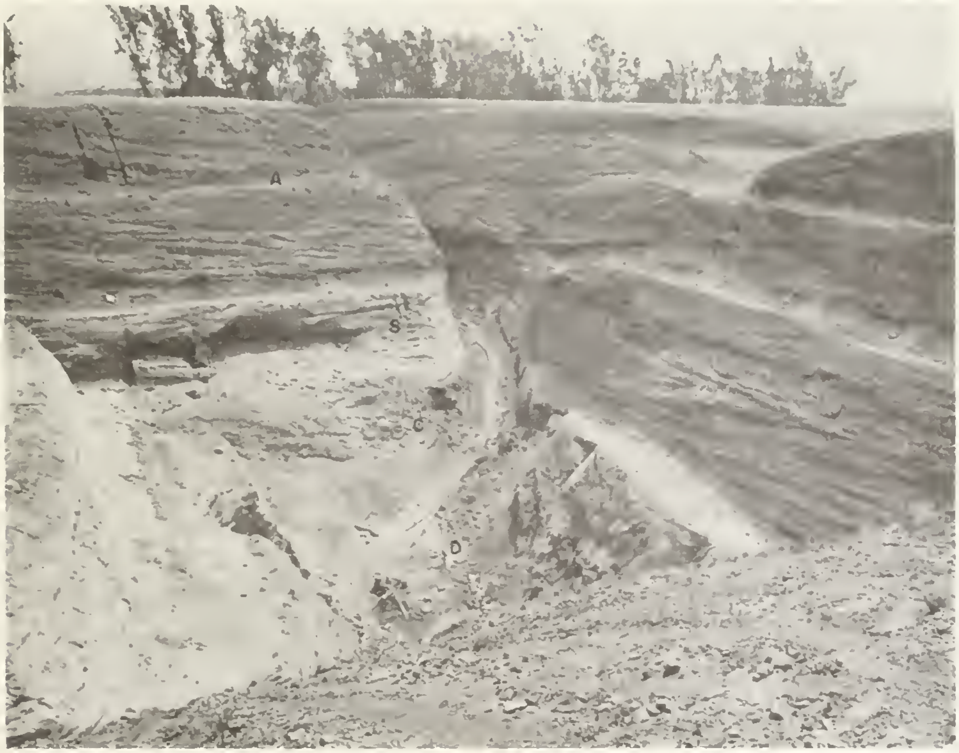


Figure 7. Bedford Canyon clay mine of Gladding, McBean and Company, during initial development in early 1955. Hornblende diorite (D) is overlain by residual red mottled clay (C, mapped with the Paleocene Silverado formation), Silverado formation arkosic sandstone (S), and older alluvium (A). Observer faces southeast. *Photograph by David P. Shelhamer, Los Angeles, California, courtesy of Gladding, McBean and Company, Los Angeles, California.*

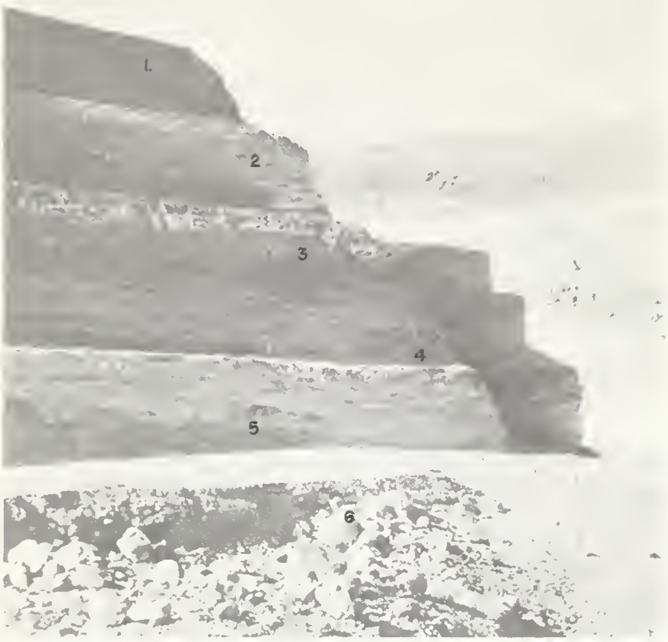


FIGURE 8. Bedford Canyon clay mine of Gladding, McBean and Company, November 1956. Hornblende diorite (6) is overlain by residual red mottled clay (5, mapped with Paleocene Silverado formation), arkosic sandstone (4), sedimentary red mottled clay (3), and coarse arkosic sandstone (2) of the Silverado formation, and sandy older alluvium (1). Observer faces northwest. *Photograph by George B. Cleveland.*

Because of the alluvial cover the deposit was missed by earlier prospectors using only surface methods of exploration such as shallow bulldozer cuts or hand trenches.

The deposit includes both residual clay and sedimentary clay of the Paleocene Silverado formation; the two clay zones are separated by poorly indurated arkosic sandstone (figs. 6, 7, 8). The beds appear to strike about N. 20° W. and dip from 8° to 15° southwest. The sequence, as exposed in the pit in October 1955, is given below.

Unaltered, fine-grained, blackish-gray hornblende diorite (phase of the Corona hornblende granodiorite porphyry) grades upward through progressively more altered rock, but with igneous texture recognizable, and finally into red mottled residual clay without recognizable igneous texture. This zone is mostly red with some buff colored pods and ranges from 5 to 20 feet in thickness, with an irregular and discontinuous pisolitic zone at the top as much as 4 feet thick. The top of the residual clay is an undulating erosion surface which is overlain by 5 to 15 feet of tawny to buff, medium to coarse, poorly consolidated arkose which contains much mica, and abundant pearly gray anauxite. The lower part of the arkose contains sparse, irregularly shaped, cobble-sized clasts of red mottled residual clay and a thin, discontinuous basal conglomerate with pebbles and cobbles of quartz.

Overlying the arkose are 10 to 15 feet of red mottled sedimentary clay with some white, gray, and buff colored pods. Bedding is not discernible and the sedimentary clay has the same appearance as the residual clay. In places, a thin zone of altered conglomerate lies at the base of the sedimentary clay. This zone contains light colored angular cobbles of altered igneous rocks and is cemented with a red, sandy, pisolitic clay matrix. The top of the sedimentary clay is a gray to buff or tawny colored pisolitic zone from 1 to 5 feet thick. In places the uppermost part of this zone has been bleached to nearly white. The sedimentary clay is overlain by 10 to 100 feet of buff to gray and white, poorly indurated, fine to medium, arkose which contains abundant grayish-green mica and pearly gray anauxite.

Brown to dark gray, sandy older alluvium, which contains angular cobble clasts, covers the Silverado formation and ranges from 20 to 50 feet in thickness. In places, the Silverado arkose has been channeled and filled with the older alluvium which contains zones of stream gravel and zones of gray, fine-grained, cross-bedded stream sand and silt. Recent alluvium fills the bottom of Bedford and Joseph Canyons. At the west edge of the pit, fossiliferous middle Miocene (Topanga) sandstone apparently overlies, but may be faulted against, the Silverado formation. At the time of the writer's visit (July 1956), the actual contact was not observed but was covered with material from the excavation.

Both the red matrix material and pisolitic inclusions of the upper part of the sedimentary clay are chiefly kaolinite as indicated by x-ray diffraction analysis.

One sample collected by the writer from the pisolitic zone of the sedimentary clay was analyzed by G. A. Uman, Sanitary Engineering Laboratory, Los Angeles Department of Water and Power as shown below:

I X-ray diffraction analysis
  A. Red matrix material
    1. Kaolinite
    2. Hematite or hydrohematite
  B. Pisolitic inclusions
    1. Kaolinite

II Spectrographic semi-quantitative analysis

Element	Concentration
Aluminum	Major constituent
Silicon	Do.
Iron	Do.
Trace elements (in decreasing order of concentration)	
Titanium	Between 0.2% and 0.001%
Magnesium	Do.
Manganese	Do.
Boron	Do.
Gallium	Do.
Vanadium	Do.
Barium	Do.
Chromium	Do.
Silver	Do.

Most of the deposit is common red-burning clay but the pisolitic material which comprises a small part of the total thickness appears to be a low-grade fire clay. This pisolitic material resembles the alumina-rich clay found at the Middlesworth deposit (described herein). The operator recognizes and expects to blend five or six different pit clays. The distinctions most easily made in the field are as follows:

1. Sedimentary clay
   1. Uppermost part: tan to white, bleached, altered pisolitic zone. Locally termed "upper bone clay".
   2. Upper part: red-brown and gray pisolitic zone. Locally termed "upper bone clay".

   3. Lower part: red, white, and gray mottled clay. Locally termed "red mottled clay".

II. Residual clay
   1. Top of residual clay: red pisolitic zone, iron-rich pisolites abundant, locally termed "bone clay"; grades downward to red mottled clay containing sparse iron-rich pisolites, locally termed "semi bone clay".
   2. Upper part: red and tannish-gray mottled clay; altered hornblende diorite, igneous texture destroyed.
   3. Lower part: maroon, red, and purplish mottled clay with a few pods of light green mottled clay; altered hornblende diorite, igneous texture recognizable.

Drill-hole data indicate that the Silverado formation has a maximum thickness of about 200 feet in this area. The commercial clay zones are from 40 to 150 feet in total thickness and average 100 feet. The overburden ranges from about 20 to 50 feet in thickness, and averages 30 feet throughout the property. However, to the west and southwest toward the Santa Ana Mountains, the overburden reaches 200 feet in thickness or more and therefore these areas could not be economically mined under present conditions. The operators state that the proved reserves of high-grade red-burning clay are sufficient to supply the plant for 50 years, and that the property has estimated reserves of over 10 million tons of all types of red-burning clay, or enough to keep the plant in operation for 100 years (Ceramic News, November 1956, p. 22).

During the initial development, early in 1955, a number of closely spaced core holes were sunk in the northwest part of sec. 16, T. 4 S., R. 6 W., in the lower reaches of Bedford and Joseph Canyons. Stripping operations, carried on with bulldozers, rippers, scrapers, and tournapull-type equipment, began in 1955. About 100,000 cubic yards of overburden were removed in developing the exploratory pit which is southwest of Highway 71 between the east edge of El Cerrito Hills and lower Joseph Canyon. The overburden was used as fill for leveling the plant site and storage yard in lower Bedford Canyon. When the pit was opened, about 3,000 tons of clay including five or six different "types" were mined and stockpiled. Various amounts of these several clay "types" were blended to form a sample which was used to make sewer pipe in a test run at the Glendale plant of Gladding, McBean and Company. It is reported that extensive test runs of vitrified clay sewer pipe yielded satisfactory results. A total of 15,000 tons of clay have been mined for testing purposes (Ceramic News, November 1956, p. 22). The property was mostly inactive during early 1956 but in July large scale stripping operations were resumed and some clay was stockpiled. The pit (fig. 8) has been inactive since July 1956 and probably mining will be periodic, with sufficient clay being stockpiled to supply the plant for many months. By early 1957 the pit was approximately 700 feet long in a north-south direction, 200 to 300 feet wide and 125 feet deep.

Construction of the plant, at an estimated cost of $5,000,000 and designed for the manufacture of vitrified clay pipe for sewer lines and storm drains and multiple duct vitrified clay conduit for telephone and power lines, was begun in July 1956. The Bedford clay, blended with clay from the company's Sloan pit at Alberhill and several local filler clays will be utilized. The filler clays include Silverado formation clay shales from the Thomas clay deposit (described herein) and clay shale and clayey sand of the Sycamore Canyon member of the upper Miocene Puente formation from the Pomona Brick Company's Strona pit on the northeast flank of the Chino Hills (sec. 1, T. 3 S., R. 8 W., S.B.M.). The plant will house a 420-foot tunnel kiln and 8 periodic or "beehive" kilns. Buildings will include bulk clay and grog storage bins; grinding and screening building with two 10-foot grinding pans; a structure housing seven auger presses and 16 horizontal and vertical dryers; laboratories and offices; lunch room and locker building; and main offices. About 90 persons will be employed (Ceramic News, August 1956, p. 17).

The initial rated capacity will be 6,000 tons per month. This will be expanded gradually to 12,000 tons per month in about 3 years.

Corona Placer (Lord). Location: NW¼ sec. 14, T. 4 S., R. 7 W., S.B.M., about 3½ miles southwest of Corona on the ridges northwest of Main Street Canyon. Ownership: A. E. Ganahl, 1011 Victoria, Corona, owns one patented placer claim (Corona Placer) and six unpatented placer claims (Corona Placer Nos. 2, 3, 4; Scorpio Nos. 1, 2, 3) totaling over 100 acres.

The Corona placer may include at least part of the clay and mineral paint deposits worked by George W. Lord and others about 1900 (Aubury, 1906, pp. 223, 339). The claim was originally located by Mr. Lord, but the patent was issued to H. E. Ganahl in 1914. The Corona Placer claims Nos. 2, 3, 4 were located in 1916 by Fidel Ganahl and the Scorpio claims were located by Weldon Draper in 1943. In 1957 all of these claims were held by A. E. Ganahl.

The deposits are thin, discontinuous, red mottled and pisolitic "bauxitic" clays of the Paleocene Silverado formation intercalated with clay shale, arkosic sandstone and conglomerate. The Silverado beds strike northwest and dip steeply southwest, or are vertical. In general the deposit is believed to be similar to, and an extension of, the adjoining Middlesworth deposit (described herein). However, in 1957 slumping of the old workings and dense brush made detailed mapping of the Corona placer impracticable. Tucker and Sampson (1945, p. 161) reported a bed of "blue fire clay" said to be 20 feet thick with 10 to 20 feet of overburden. G. W. Lord is reported to have produced gray fire clay, about 1905, which probably was mined from this property and the adjoining Middlesworth deposit to the northwest. However, fire clay is not now exposed and clay reserves appear to be small.

By 1914 the property had been developed by two open cuts and two adits, each about 100 (?) feet long. These workings are now inaccessible. The property has long been idle, except for annual assessment work which has included stripping by bulldozer and road building. Amount of production is not known, but probably was not large.

Grapevine Clay Mine. Location: Lot 9, sec. 4, T. 4 S., R. 7 W., S.B.M., about 3 miles southwest of Corona on the south side of Mabey Canyon. Ownership: Mrs. Mary A. Mattey, 11359 Biona Avenue, Los Angeles 66, California, owns one unpatented claim (Grapevine placer) of about 12 acres. Application for patent was filed with the U. S. Bureau of Land Management in Los Angeles in January 1956.

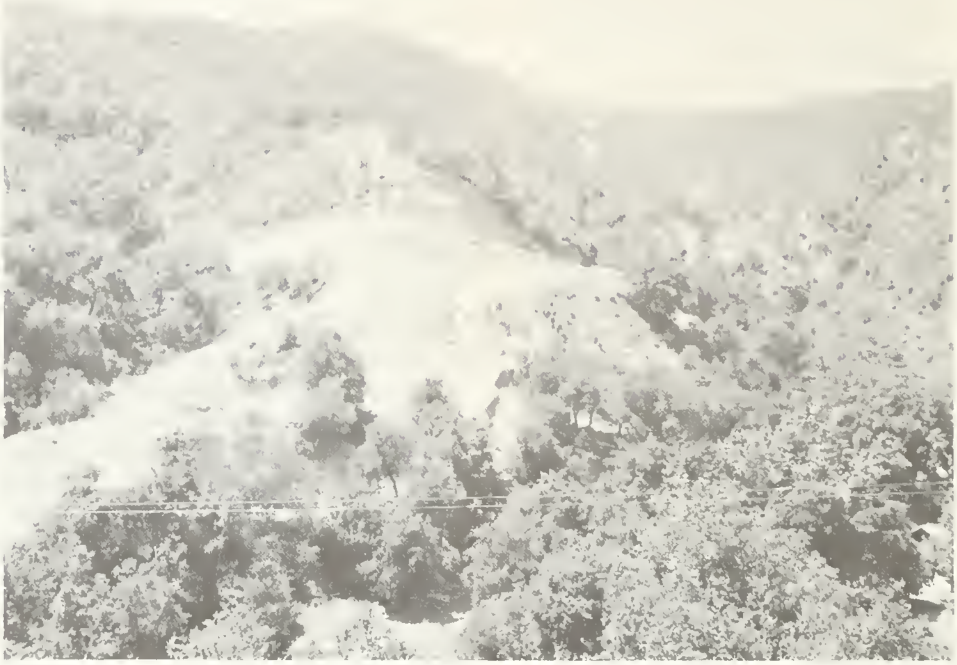


Figure 9. Quarry at the Grapevine clay shale deposit, south side of Mabey Canyon. The quarry face is about 25 feet high and exposes claystone of the Holz shale member of the Upper Cretaceous Ladd formation. Material is loosened by bulldozer and pushed to a loading chute bunker (fig. 10) hidden by trees at lower left below quarry. Observer faces southwest.

The Grapevine clay deposit was located by Joseph Erenreich many years ago, apparently as a lode claim, and, after lapsing, was relocated by him in 1945. Shortly thereafter the property was acquired by Robert A. Mattey and passed to Mrs. Mattey in 1952. The earliest period of activity was from about 1900 to 1910. In 1906 the California Portland Cement Company removed some "cement rock" by team and wagon and about 30,000 tons are said to have been shipped to their Colton plant (personal communication, Mrs. R. A. Mattey, Nov. 1956). From 1908 to 1910 the Corona Pressed Brick Company is reported to have used clay shale from this deposit in their manufacturing plant located west of Corona. After 1910 the property remained idle except for development work, until about 1950 when Joe Deleo, Corona, mined some clay shale. Starting in 1953 the Sky Ranch Clay Company began mining this clay shale, on a royalty basis, for use by the Tillotson Refractories Company in Corona. During 1955 production was about 350 tons per month. The property was idle in November 1956.

The clay occurs as a clay shale unit in a narrow lens of the Holz shale member of the Upper Cretaceous Ladd formation. This lens of Holz shale, about 3,500 feet long and as much as 500 feet wide, crops out along the abruptly rising south side of Mabey Canyon. The shale strikes about N. 60° W. and dips 65° northeast or is vertical. The Grapevine claim covers only about 1000 feet of the strike-length along the central part of the shale, the remainder on each end being part of the Sky Ranch Clay Company holdings (described herein). This material is used as a constituent in the manufacture of common red-burning clay products.

Development consists of several short exploratory adits and open cuts (fig. 9). Three adits were driven

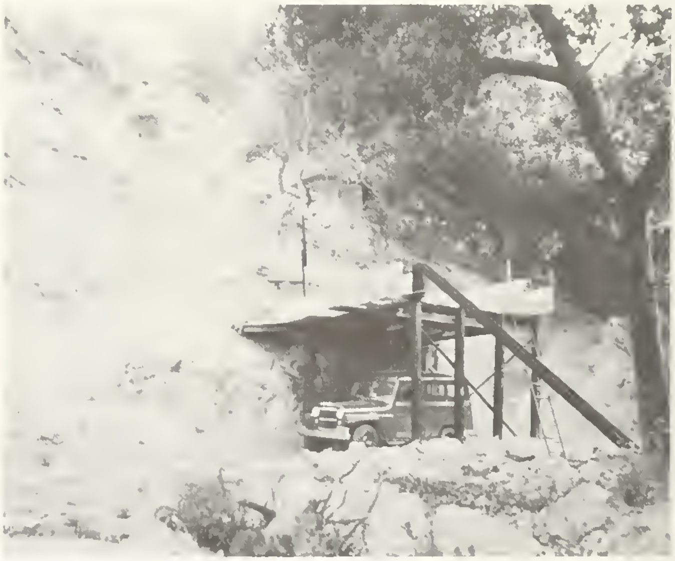


Figure 10. Loading chute-bunker at Grapevine clay shale deposit. Loosened clay shale is pushed into bunker from quarry above (figure 9) by bulldozer. This illustrates the typical method used for many years to load trucks at most of the clay deposits in the Corona area. Skiploaders (fig. 18) have replaced this method in most operations. Observer faces southwest.

during early development operations; one is now caved at the portal, two others are 50 and 60 feet in length. Recent mining was done by benching with bulldozer, ripper, and scraper, the loosened material being pushed into a small storage bunker (fig. 10) for loading into small trucks.

Jones (Hoffman, Hoag Ranch) Clay Deposit. Location: NW¼ sec. 19, T. 4 S., R. 6 W., S.B.M., near the head of a small canyon midway between Joseph and Bedford Canyons. Ownership: Mrs. D. C. Hammond, 2955 E. California, Pasadena, California, owns about 400 acres of ranch land (purchased by Coronita Ranch, c/o D. C. McMillan, 8704 Colima Road, Whittier, California, in late 1957).

The Jones clay deposit, known in 1892 as Hoffman's coal prospect, was later part of the Hoag ranch. The owner in 1925 was A. E. Jones of Corona; later the property was acquired by Mrs. Hammond. Local residents report the period of greatest activity as about 1900 when clay and coal were mined.

The mine area, which is covered with dense brush, is along the northeast side of the Elsinore fault. These deposits are part of the nonmarine lower facies of the Paleocene Silverado formation. The strata now exposed in the mine area are white arkosic sands, sandy buff to gray claystone, cobble conglomerate and tawny and gray fissile claystones which strike northwest and dip about 30° southwest; the beds are overturned. The commercial clay zone is not exposed but presumably occurs below the white arkose. Tucker and Sampson (1929, pp. 500-501) describe the clay in the workings as a gray, plastic clay bed approximately 6 to 8 feet in thickness, dipping southwest about 20°. Thin coal seams occurred on both the top and bottom of the clay bed. The coal seam at the outcrop was from 4 to 10 inches thick and is reported to have been 4 feet thick in old workings 90 feet from the surface.

According to Tucker and Sampson (1929, pp. 500-501) the principal mine workings were at the head of the canyon and consisted of 4 adits ranging from 70 to 180 feet in length. These adits were driven on the two coal seams. The production of clay from this property probably was small and the coal is said to have been used only locally. The property was idle in 1925 and apparently has since remained idle. In 1956 all of the workings were badly caved and only several old mine rails and some scattered dump material mark the site.

Jordan Tile Manufacturing Company. Location: 909 Railroad Street, Corona, in the NE¼ sec. 26, T. 3 S., R. 7 W., S.B.M. (projected), in Corona North quadrangle. Ownership: Mosaic Tile Company, Zanesville, Ohio.

At the plant of the Jordan Tile Company, built in 1948, three types of tile are manufactured and include: (1) "vitreous" tile, used to make unglazed ceramic mosaic; (2) "quarry" tile, used on industrial floors and walls; and (3) "Granitex", assembled in sheets and used on floors and walls. As the company has no mining properties, raw materials are purchased from a number of suppliers. This plant (fig. 11) has two complete circuits, one for "vitreous" tile and "Granitex", and the other for "quarry" tile, and is the principal supplier of these products in southern California.

Raw materials used in the "vitreous" tile include talc from Gouverneur Talc Company, Inc., New York; feldspar from the Consolidated Feldspar Department of the International Minerals and Chemical Corporation, Kingman, Arizona; silica, feldspar, and silica spar from Del Monte Properties Company, Pacific Grove, California; kaolin from the southeastern states, including Georgia and Florida; and small amounts of stain to produce the desired colors. After pugging, the mixture is put through manually operated presses which make 5 to 20 tiles, depending upon the size. Most of the tile is made in one-half to one inch squares, but various sizes and shapes are made and some tiles are as much as 2 inches square. The pressed raw tiles are hand-trimmed to remove rough edges, stacked on kiln cars, and fired in a tunnel kiln. The finished "vitreous" tiles, which are made in various colors, are hand-assembled into any desired mosaic pattern and have found a wide range of use in the building industry.

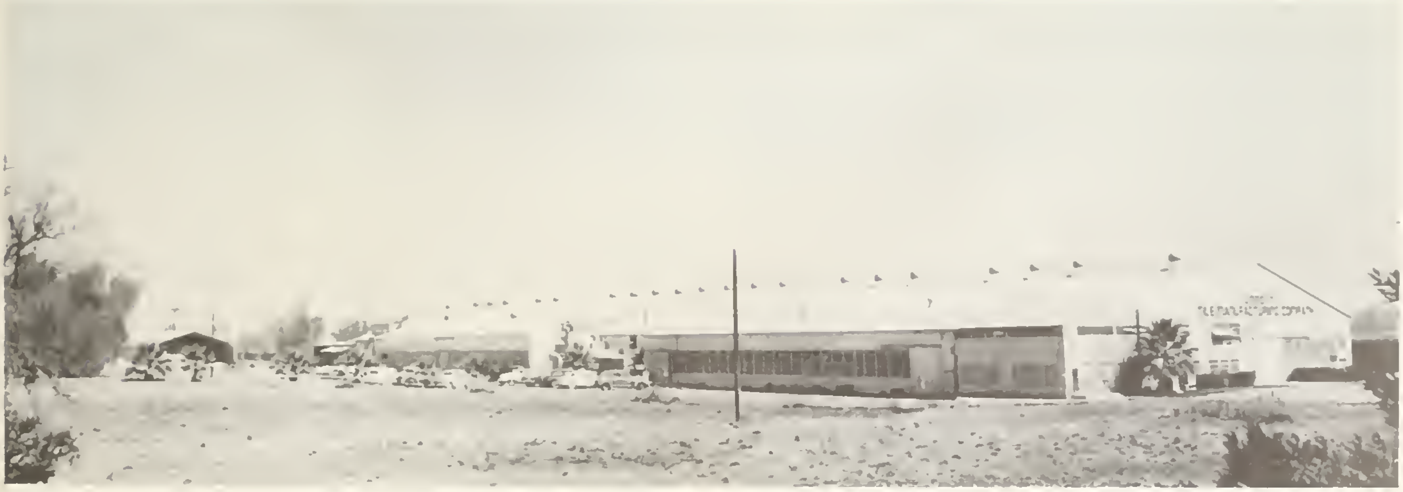


FIGURE 11. Jordan Tile Manufacturing Company plant, Corona. Raw material storage is in open building at left background. Large building houses pugging machines, presses, tunnel kilns, storage and shipping facilities and offices. One of the first clay pipe manufacturing plants in the Corona area—the Pacific Clay Manufacturing Co. (fig. 1)—occupied this site from about 1900 to early 1920's. Observer faces northwest.

Red, brown, buff and gray colored "quarry" tile, in several sizes, is manufactured from California raw materials, mostly from nearby quarries in the Silverado formation. These include white, sandy fire clay from the Sloan Number 1 pit of Gladding, McBean and Company at Alberhill; red mottled clay from the Harrington and Atlas clay pits 8 miles southeast of Corona along the east side of Temescal Wash; clay shale from the Thomas clay deposit, east pit (see herein); and waste clay from the processing of clayey sand at the Corona silica sand deposit (see herein). Lesser amounts of fire clay from Lincoln and Ione, California also are used. No artificial coloring is added, the earthy colors coming from the clays. After pugging, the clay mixture for "quarry" tile is extruded, cut in various sizes, and fired in a tunnel kiln. The finished tile is then packaged in cardboard boxes for rail or truck shipment.

"Granitex" is a trade name for a tile which is related to both the "vitreous" tile and "quarry" tile. It is pressed, as the "vitreous" tile, but like "quarry" tile, it is made of and colored by, natural clays from the Corona area. The "Granitex", made in various shades of brown and red, has a speckled appearance and the tiles are assembled in sheets similar to the unglazed ceramic mosaics made with the "vitreous" tile.

Kroonen Clay Deposit (Keno Group; Dutch Placer). Location: S½ sec. 4; NE¼ sec. 9; NW¼ sec. 10, T. 4 S., R. 7 W., S.B.M., about 3 miles southwest of Corona between Tin Mine and Mabey Canyons. Ownership: Mary L. Kroonen, 708 West Eighth Street, Corona, California, owns eight patented placer claims: Victor, Little Canyon, Dutch Republic, Big 4, White Clay, Kroonen, Black Chief, and Keno totaling about 150 acres. John Tillotson, 807 Park Lane, Corona, owns the Leo Lorenzo placer claim (20 acres) originally included in the Kroonen group.

The Kroonen group is adjacent to the old McKnight mine and probably the early exploration occurred during the same period, about 1890-1900. The property had been sufficiently developed so that patent was applied for in 1914. It was granted in 1917 to Leo Kroonen, Corona. By 1928 the property was idle but had been developed by tunnels and open cuts (Tucker and Sampson, 1929, p. 501). In 1956, the tunnels had been made inaccessible by caving and the cuts were slumped, but clay exposures were observed in several open cuts. The amount and the exact period of production are unknown, but this property probably furnished red-burning and perhaps some fire clay to several nearby clay products manufacturing plants which were active about 1900 to 1920. The property apparently has been idle for many years.

In the northwest part of the deposit, where most of the mining appears to have been done, red mottled clays with good plasticity and thin lenses of dark gray, dense, kaolinite clays associated with lignite are intercalated with buff clay shales, thin-bedded micaceous sandstone, and conglomerate. The beds, which are part of the Paleocene Silverado formation, strike northwest and dip vertically to steeply overturned to the southwest. These beds are much disturbed by faulting and form the narrow part of a wedge-shaped fault sliver of Silverado formation sedimentary rocks. The clay beds are not well exposed but the red mottled clay may be as much as 10 feet thick while the kaolinite and lignite zones range from several inches to one foot in thickness. The lateral extent is not traceable more than several tens of feet. Reserves of clay appear to be small.

Liston Brick Company. Location: SE cor. NW¼ sec. 16, T. 4 S., R. 6 W., S.B.M., on State Highway 71 about 5½ miles southeast of Corona, on the east side of lower Bedford Wash. Ownership: Lionel P. Liston, P. O. Box 4, Corona, California.

The Liston Brick Company manufactures common brick products in both common and commercial sizes. This plant (figs. 12, 13) was established in 1948 by Mr. Liston, who had previously operated the Coast Brick Company in Torrance. The processing includes grinding and mixing of several raw material components. After pugging, a vacuum pump removes air and the mixture is extruded under pressure. Various brick sizes are cut and placed in a curing yard. After curing about 5 weeks, the bricks are fired in a field kiln—the final operation. About 20 workers are employed, including the plant crew and sales personnel.

The company purchases all of the mineral raw materials used from producers in the Corona South quadrangle. These materials are furnished from three sources: (1) diatomaceous shale of Miocene age is supplied from the Chocolate Drop deposit (figure 15; see tabulated list); (2) Owens-Illinois Glass Company provides sandy clay stripping waste material from the quarry at their nearby glass sand plant; and (3) small amounts of local soil are sometimes used.

McKnight Clay Mine. Location: NE¼ sec. 9; SW¼ sec. 3; NW¼ sec. 10, T. 4 S., R. 7 W., S.B.M., along the south side of Kroonen (Richardson) Canyon about 3 miles southwest of Corona, between Tin Mine and Mabey Canyons. Ownership: Pacific Clay Products, 1255 West Fourth Street, Los Angeles, California, owns three patented placer claims (Lucky, Trio, and McKnight), and one unpatented claim (Old Shaft), totaling about 65 acres.

Development of the McKnight deposit began about 1885 with the discovery of coal (Goodyear, 1888, p. 505). Coal mining proved to be unprofitable, but attention was soon turned to the associated clay beds. Crawford (1896, pp. 616-617) reports that 200 tons of clay per month were shipped by J. H. McKnight to plants in South Riverside (Corona) and Los Angeles during 1896. By 1905 the property had been acquired and patented by the Pacific Clay Manufacturing Company, Los Angeles; before 1915 holdings of this company were acquired by the Pacific Sewer Pipe Company which later became the Pacific Clay Products Company, now known as Pacific Clay Products, the current owner, and the operator of the property for many years.

The McKnight mine was closed down during the middle or late 1930's and has since remained inactive except for small intermittent production of red-burning clay from open pits. The amount of production is not known, but judging from the extent of the workings and fragmentary reports, a large tonnage of both red-burning claystone and fire clay must have been produced over a period of activity spanning nearly 50 years. However, by today's standards, it would not have been considered a large mine at any time.

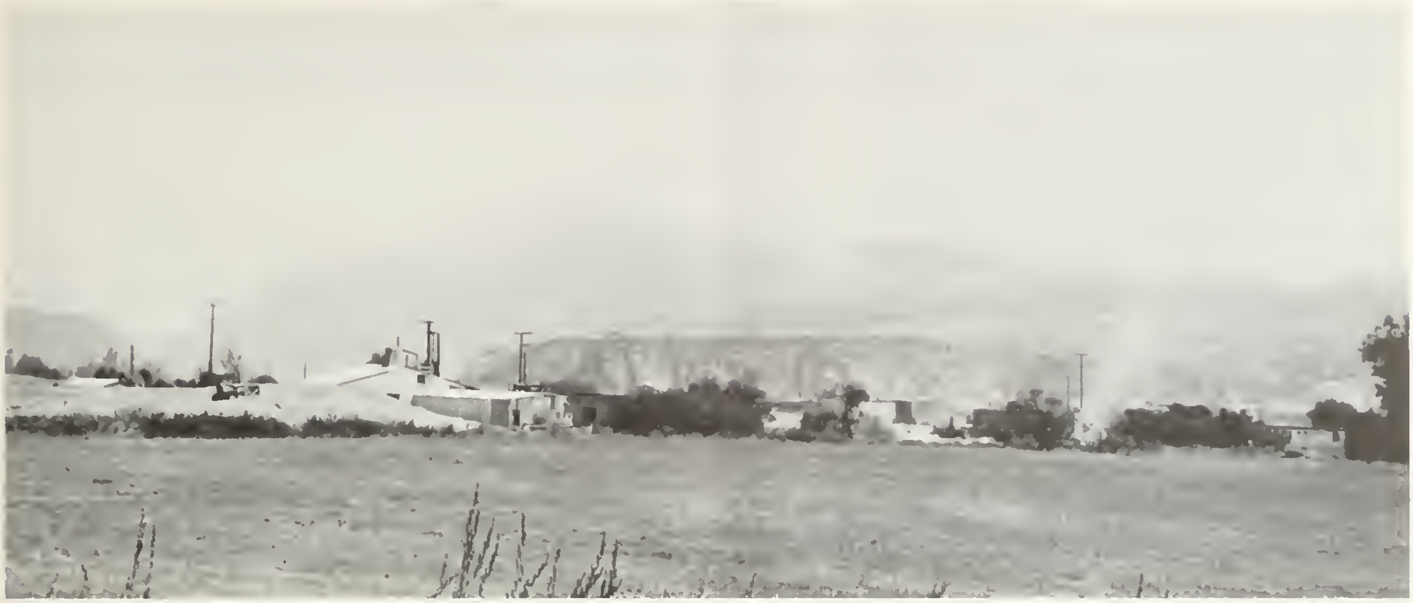


FIGURE 12. Liston Brick Company plant in lower Bedford Wash. Raw materials (left) are blended by bulldozer. Building left of center houses pugging, extruding, and cutting machines. After curing the bricks are fired in field kilns (right middle distance). Observer faces northeast.

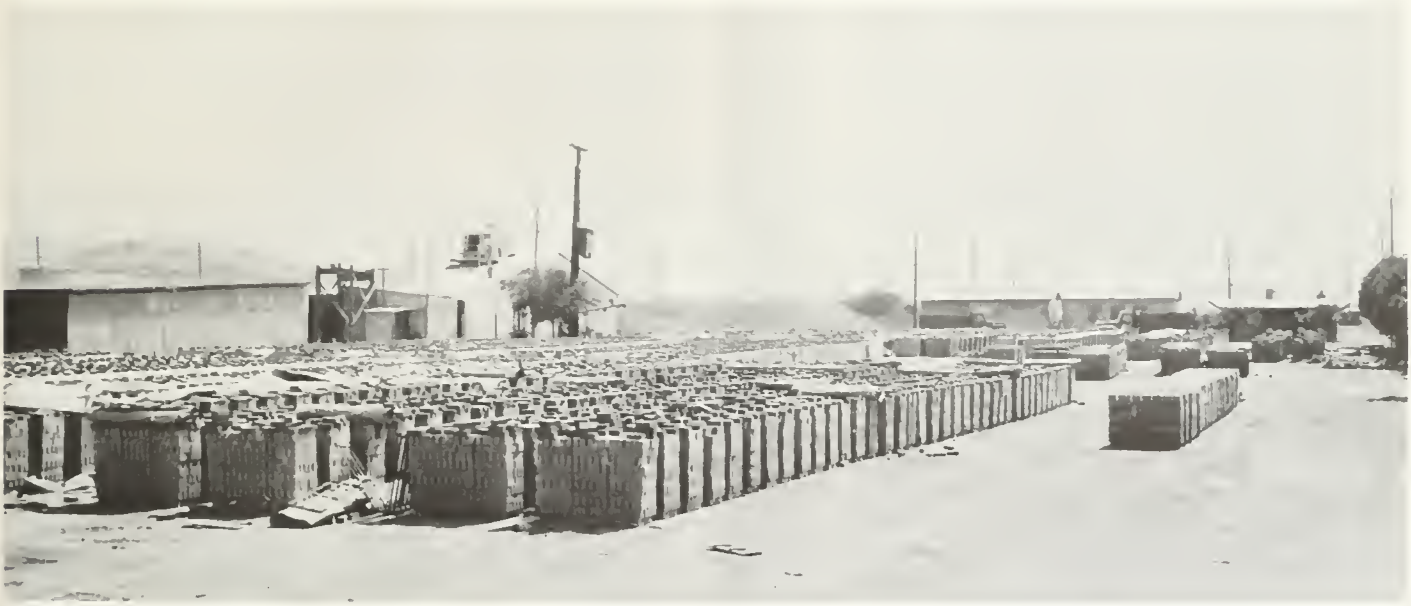


FIGURE 13. Plant and finished brick storage yard of Liston Brick Company, lower Bedford Wash. Plant (left background), raw clay stockpile (center background), office and shop (right background), finished brick storage in foreground. Observer faces southwest.

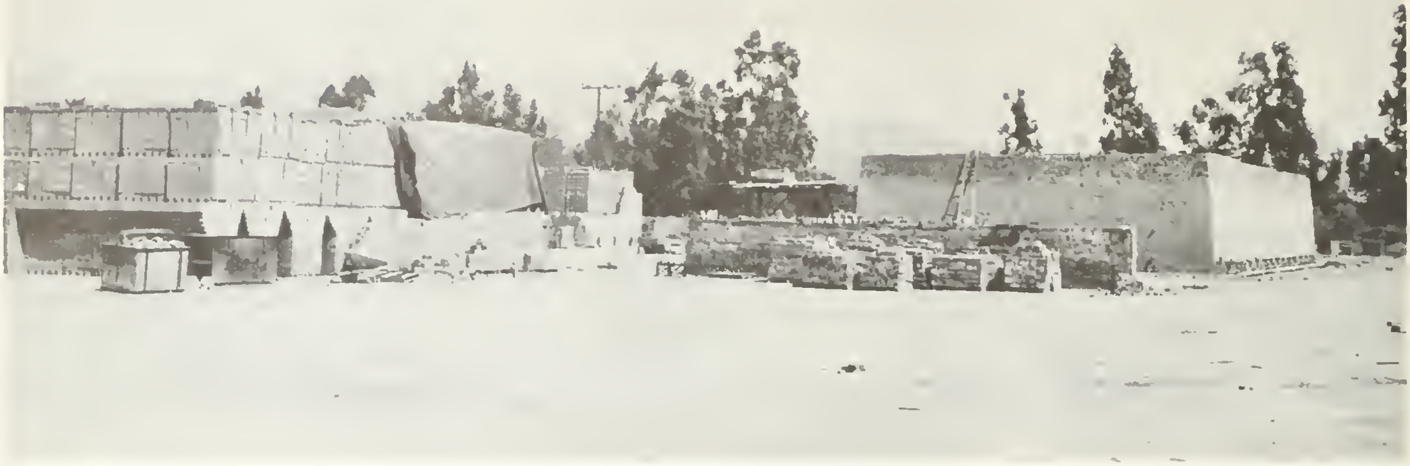


FIGURE 14. Field kilns of Liston Brick Company. Bricks in left foreground have been stacked to form a field kiln and the outside kiln wall is being erected. Kiln in left center background has been fired and the outside kiln wall is being removed. Kiln in right center foreground has been fired and almost completely dismantled. Kiln in right background has the outside wall erected, sealed with "mud" and pipes installed, ready for natural gas firing. After firing the walls are removed and the brick is sold directly from the kiln piles. Observer faces southeast.

FIGURE 15. Chocolate Drop clay shale deposit. Topanga formation (middle Miocene) diatomaceous shale is mined by bulldozer and loaded by skip loader on trucks for transport to the nearby Liston Brick Company, where the shale is used in the manufacture of common brick products. Observer faces southeast.

The McKnight deposit is in the sedimentary clay series of the Paleocene Silverado formation, and includes iron-stained clay shale, red mottled clay and gray fire clay. The clay beds crop out in several open pits and cuts on a low, brush-covered hill along the south side of Kroonen Canyon. The clay section is not completely exposed, but fragmentary exposures and previously published descriptions suggest that the McKnight sequence is similar to the sedimentary sequence at Alberhill. According to Dietrich (1928, p. 179) the McKnight deposit consisted of two principal layers of commercial clay; an upper layer, 60 feet thick, of red burning material, and used in the manufacture of common clay products; and a lower layer of fire clay, 30 feet thick, used for fire brick. Results of extensive laboratory tests of these two clay types are given by Dietrich (1928, p. 277). The clay deposits are intercalated with sandstone and conglomerate. They are underlain by green, buff, and reddish-brown sandstone and overlain by clay shale which is stained pink or red by iron oxides. This shale was used early as red-burning clay (Sutherland 1935, p. 77). According to Sutherland (1935, p. 77) most of the mined clay was a flint-fire clay, moderately sandy and well-indurated and containing various proportions of very fine-grained, gray to black, disseminated carbon. The carbonaceous material is concentrated in places in lenses and pockets of coal which contain occasional lenses of pisolitic clay. In other places an extremely hard, light-gray fire clay occurs without the more extensive black fire clay. Analyses from Pacific Clay Products are as follows (Sutherland 1935, p. 78):

	Black McKnight clay (fire clay) *Percent*	*Red McKnight clay (red-burning)* *Percent*
SiO_2	57.38	63.86
Al_2O_3	27.62	21.52
Fe_2O_3	2.06	4.12
CaO	1.90	.24
MgO	.11	.09
Alkalies	.13	.83
Ignition loss	10.62	8.73

The McKnight clays occur in a fault block of sedimentary rocks of the Silverado formation. The fault block is triangular in plan, and is about 6,000 feet long with a maximum width of 2,500 feet, bordered by Upper Cretaceous sandstone, conglomerate and shale of the Ladd formation, undifferentiated. The structure is further complicated by cross fractures and folding which make the clay beds difficult to mine. The Paleocene clays may rest unconformably on and be infolded with Upper Cretaceous rocks and were later disturbed by complex faulting. However the Paleocene rocks seem to comprise a fault block. Reserves of fire clay probably are meager and those of the red-burning clay are somewhat more abundant, but no meaningful estimate of clay reserves seems possible from available data.

The McKnight property was mined mostly by underground workings which literally honey-comb the mine area (Sutherland 1935, p. 79). By 1887, an adit had been driven into the hill about 60 feet and a winze about 170 feet deep sunk from the adit in a search for coal (Goodyear 1888, p. 505). At the time of patent (1905), the property had been developed by four adits, with level workings totaling about 500 feet and two small open pits. Large quantities of high-refractory clays were being mined by underground methods for use in the Pacific Clay Manufacturing Company's plant one mile west of Corona (fig. 1). Sewer pipe, water pipe, glazed and unglazed tiles, flue linings, chimney pipes, firebrick, electric conduit, and terra cotta were among the products manufactured at this plant. The fire brick was made from the refractory clay of the McKnight mine while the common clay products were made from Temescal Valley clays obtained southeast of Corona (Aubury 1906, p. 224).

The Pacific Sewer Pipe Company was operating the McKnight mine in 1915 and was using the refractory clay to manufacture fire bricks (Acorn brand) at Corona (Merrill 1919, pp. 569, 570). Boalich (1920, pp. 89-90) reported that flint-fire clay was mined in 1919 from a vertical shaft 130 feet deep and that two men were employed at the mine. Fire brick from the McKnight clay and common clay products from Temescal Valley clays were manufactured at the Corona plant which employed 50 to 60 persons. According to Dietrich (1928, p. 179) Pacific Clay Products was mining fire clay in 1925 from the McKnight property through a lower adit 410 feet long and an upper adit 70 feet above and 500 feet to the west. The two adits were connected by a raise; clay was mined by room and pillar methods, dumped into the raise, and drawn off into small mine cars in the lower adit. The rooms were about 15 feet high and connected with an open pit and adit at a still higher level from which red-burning sewer pipe clay was being mined. Extensive workings of a similar character were to the southeast, but the clays there had been exhausted some years before 1925. Reserves of fire clay were believed to be small, but a considerable tonnage of red-burning sewer pipe clay remained (Dietrich 1928, p. 179). Mining and loading was by hand methods and output in 1925 was 50 tons per day each of red-burning and fire clay. The clay was trucked to a railsiding for shipment to the plant in Los Angeles, the Corona plant having burned down several years earlier. Production of red-burning clay ceased several years later but fire clay was still being mined in 1931, overhead stoping methods being employed (Sutherland 1935, p. 78). The property has been idle since about the middle 1930's, except for small intermittent production of red-burning clay from open pits and occasional sampling. In 1942 a small tonnage of red "ladle" clay was supplied to Pacific Clay Products Lincoln Heights plant in Los Angeles and about 1952 several hundred tons of red-burning clay were mined. By 1945 the main workings were caved and inaccessible. At present (1958) several small adits are open but show little clay; several open pits above the old underground workings partly expose the clay sequence. There are no plans to reopen the property.

Middlesworth Clay Deposit (Brown Star Claims; Lord ?, Freeman ?). Location: NW¼ sec. 14; SW¼ sec. 11; NE¼ sec. 15, T. 4 S., R. 7 W., S.B.M., about 3½ miles south of Corona along the canyon (Lords Canyon) and intervening ridges midway between Main Street and Hagador Canyons. Ownership: Josephine Middlesworth, 847 West 9th Street, Corona, California, holds three unpatented placer claims (Good Luck, Good Hope, Valley Brief) in the NW¼ sec. 14 totaling about 37 acres. William H. Redding, et al., 1008 South Pacific Avenue, San

Pedro, California, own 105 acres of patented ranch land (N½NE¼ sec. 15; SW¼ sec. 11) and one unpatented placer claim (Red Bull No. 1, S½SE¼ sec. 10) of about 80 acres. Patented ranch land totaling 12.5 acres in the N½NW¼NW¼ sec. 14 was owned in 1944 by Mrs. Mabel M. Freeman, Riverside, California.

This property apparently now embraces part of several clay and mineral paint deposits operated as early as 1905 by George W. Lord (Aubury 1906, p. 203) and later by G. R. Freeman who intermittently produced crude clay from 1918 to 1937. Some of this production may have come from an extension of these clay deposits southeastward to Main Street Canyon (Corona Placer, described herein). By 1944, J. C. Middlesworth, Corona, held four 20-acre placer claims, known as the Brown Star claims; the patented areas were owned by the Freeman interests. Early development was by open cuts, shallow shafts and two adits, 150 feet in length. In 1943, the Kaiser Steel Corporation took a short term option on the property and did considerable exploratory work. The production is not known but probably was not large, and there has been none for many years.

The clays crop out in bulldozer cuts and pits adjacent to the Elsinore fault in the steeply rising foothills of the Santa Ana Mountains. The clays exposed are sandy clays and semi-plactic clays of the nonmarine part of the Paleocene Silverado formation, and consist of two principal types—a greenish-brown pisolitic "bauxite", and a semi-plastic red "pottery clay" with a conchoidal fracture. Folding and faulting have deformed the clay beds and the Silverado formation but the Silverado beds have a general northwest strike and dip from 50° to 60° NE in the mine area. However, one bed of "pottery clay" dips about 15° SW, and the largest exposure of bauxitic clay is nearly horizontal. There appear to be three beds of "bauxite" and one bed of the red material, separated by sandy clays. The "pottery clay", the basal unit of the sequence, is reported to be from 20 to 30 feet thick and is separated by about 70 feet of sandy clay from the overlying beds of impure "bauxite" which range from 2 feet to a maximum of about 6 feet in thickness (Tucker and Sampson 1945, p. 161). The "bauxite" beds, averaging about 3 feet in thickness, are exposed over an area about 300 feet square. The bottom parts of the "bauxite" beds are reported to contain a dense, hard, flinty, non-plastic clay known in the industry as "bone clay".

The latest and most extensive development work on the property was done in late 1943 by the Kaiser Steel Corporation in an effort to develop a source of alumina-rich clays (25 percent alumina, or greater) for use in steel manufacture. Detailed investigations were made of the NW¼NW¼ sec. 14, which had been idle for many years and was covered with dense brush. Bulldozers removed the brush and overburden and clay was exposed at a number of points; six new cuts were made, nine old cuts were cleaned, and two old adits were reopened. The average of 107 samples taken from surfaces thus exposed and from shallow auger holes was 18.9 percent alumina, 57.11 percent silica, and 5.11 percent iron oxide. The bauxitic clays varied from a high of 31 percent Al_2O_3 to a low of 15 percent Al_2O_3. Approximately 30,000 tons of bauxitic clay averaging above 25 percent Al_2O_3 content were proved, and an additional 30,000 tons of red clay that contains less than 25 percent Al_2O_3 (Draper, 1944).

The property was not opened as the clay did not prove to be sufficiently rich in alumina to meet the requirements, tonnage estimates were low, and there is considerable overburden which would require much stripping for full recovery. Little exploratory work has been done since 1943 and the property was idle in 1956.

Sky Ranch Clay Company Deposits. Location: W½ and SE¼ sec. 4; E½ sec. 5, T. 4 S., R. 7 W., S.B.M., about 3½ miles southwest of Corona along Mabey and Wardlow Canyons and intervening ridges. Ownership: Clifford and Maude M. Tillotson, P. O. Box 237, Corona, California, own four patented placer claims (Fire Clay No. 1, Fire Clay No. 2, M & M placer, and Susie); and three unpatented placer claims (Insight No. 1, Insight No. 2, and Frenchy placer) totaling about 170 acres. They also own clay-bearing patented ranch land in the S½NE¼ sec. 5 (Sky Ranch clay mine, west pit) and in the NW¼SE¼ sec. 4 (McClintock pit), totaling about 85 acres. John Tillotson, 807 Park Lane, Corona, owns one patented placer claim (Leo Lorenzo, 20 acres) formerly part of the Kroonen group which is described elsewhere in this report. These properties are operated collectively by the Sky Ranch Clay Company, P. O. Box 398, Corona, California.*

The clay-bearing area lies along Mabey and Wardlow Canyons and the intervening east-trending ridges, where Paleocene clay and Upper Cretaceous clay shale are exposed in cuts and pits made in the steep, brush-covered hills. The McClintock pit, the easternmost deposit, is along the north side of Mabey Canyon. To the west the Susie pit occupies a saddle midway between Wardlow and Mabey Canyons and the Fire Clay group adjoins the west edge of the Susie pit. The Frenchy placer (Sky Ranch clay mine, east pit) is astride Wardlow Canyon and adjoins the north boundaries of the Susie pit and Fire Clay group. The Sky Ranch clay mine, west pit, lies along the north side of Wardlow Canyon west of the Frenchy placer.

Operations in the vicinity of the patented properties began about 1900 when a small tonnage of clay was shipped from the Susie claim (McVicar pit) to the California Clay Manufacturing Company in Los Angeles (Aubury 1906, p. 223). The Fire Clay Nos. 1 & 2 and the M & M placer, then known as the Fire Clay group, were patented to J. H. Moore and George T. Mabey, Corona, and the Susie placer to William G. McVicar in 1913. There followed a long period of inactivity, although the Susie claim, later acquired by Earl M. McClintock, may have had small intermittent production. Additional claims were held at different times by various locators, but none is known to have been productive.

A renewal of activity began about 1945 when Earl McClintock located the Insight Nos. 1 & 2 claims. In 1946, these claims were leased to Clifford Tillotson, operator of the Sky Ranch Clay Company, who, in 1945, began developing sources of red-burning clays for use at the Tillotson Refractories Company in Corona. The

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* Pacific Clay Products, 1255 West Fourth Street, Los Angeles, California, on September 1, 1957 acquired the Susie placer claim and the patented ranch land in the S½NE¼ sec. 5 and NW¼SE¼ sec. 4, T. 4 S., R. 7 W., S.B.M., totaling about 105 acres. Mining operations continued as Pacific Clay Products, Corona shale mine.

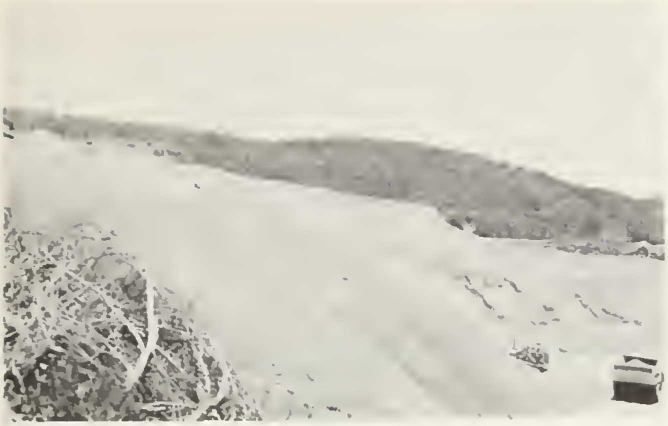

FIGURE 16. Sky Ranch Clay Company mine, west pit. Clay shale of the Ladd formation, undifferentiated (Upper Cretaceous) is loosened and stockpiled by ripper-bulldozer at left. The loosened material is loaded by skiploader (right) on trucks for transport to Tillotson Refractories Company in Corona. This is the typical method employed in mining clay shale deposits in the Corona area. Observer faces northeast.

Frenchy placer was located by J. A. Carmile in 1948. In the early 1950's the Susie claim was operated by Earl M. McClintock who furnished some clay to the Mission Clay Products Corporation at Olive, for use in the manufacture of sewer pipe. By 1955, all claims had been deeded to Mr. Tillotson, who since about 1945 had continuously produced each year several tens of thousands of tons of red-burning clay and clay shale. This has been used as a constituent in the manufacture of common clay products at the Tillotson Refractories Company, Corona (see herein). The clay shale is locally termed "Wardlow shale".

The Sky Ranch Clay Company deposits, except the Susie claim and the McClintock pit, are mostly in clay shale and siltstone of Upper Cretaceous age assigned to the Ladd formation, undifferentiated, but the clay shale on the Fire Clay group belongs to the Holz shale member of the Ladd formation. The clay shales, which contain hard, irregular limy beds and concretions, in general strike northwest, dip 40° to 80° northeast and are intercalated with sandy conglomerate and massive sandstone. The principal body of clay shale currently (1957) being mined crops out in a band about 500 feet wide along the north side of Wardlow Canyon and the shale can be traced northwestward along a strike length of 1500 feet.

The area is traversed by several northwest- to west-trending faults which, on the Susie claim, have caused a wedge-shaped block of typical sedimentary clays and lignite of the Paleocene Silverado formation to be down-dropped between two topographically higher blocks which contain sandstone and conglomerate of the Upper Cretaceous Ladd formation, undifferentiated. This structure might also be interpreted as a faulted syncline with Paleocene rocks, draped in part unconformably over Upper Cretaceous rocks. The Paleocene clays exposed in the Susie pit in 1957 included red and yellow mottled pisolitic beds 1 to 2 feet thick but exposed only for a length of several tens of feet in the central part of the pit, and a sandy white, red, greenish, and blue-gray clay zone 5 to 10 feet thick traceable for about 150 feet along a shear zone on the south side of the Susie pit. The same structure extends eastward about 2,000 feet to the McClintock pit where traces of clays similar to those in the Susie pit are exposed.

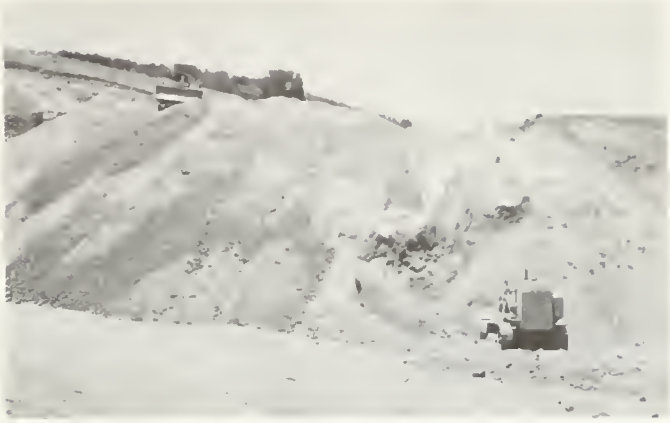

FIGURE 17. Clay shale stockpile, Sky Ranch Clay Company mine, west pit. Ripper-bulldozer (upper left) loosens the clay shale and pushes the loosened material to the stockpile from which a skiploader (lower right) loads trucks. Observer faces north.

Development has been by open cuts and short adits. By 1910 the Susie claim had been explored by three cuts and four short adits. Later mining on this claim was by open cuts which were active during the early 1950's, and by 1957 the pit area was 250 feet wide and 350 feet long. The Susie pit continues to be intermittently active. Development on the Fire Clay group included four short adits and seven open cuts in 1910. Later mining was from a small quarry, active about 1950. The McClintock pit has been explored by several shallow pits and cuts. The foregoing areas were all idle in early 1957.

Mining currently (July 1957) is in the west end of the Frenchy placer along the north side of upper Wardlow Canyon and adjoining patented ranch land to the west in the S$\frac{1}{2}$NE$\frac{1}{4}$ sec. 5 (Sky Ranch clay mine, west pit). Development of the present Sky Ranch clay mine began in 1951 when Upper Cretaceous clay shales were stripped by bulldozers. A quarry was opened on the Frenchy placer claim (Sky Ranch clay mine, east pit) about 2,000 feet east of the currently (1957) active west

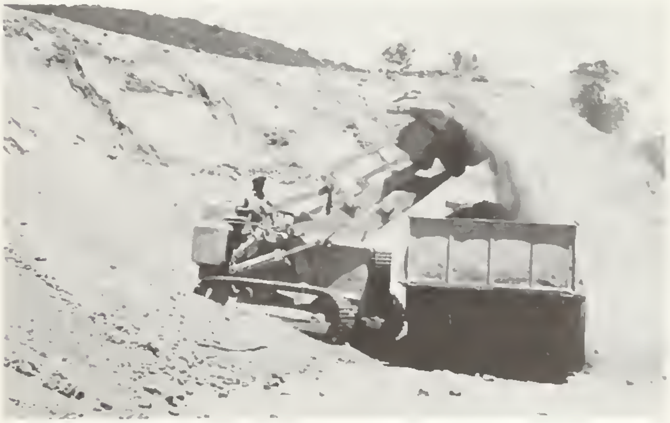

FIGURE 18. Loading clay shale, Sky Ranch Clay Company mine, west pit. Typical method of loading clay shale in the Corona area. Observer faces northeast.

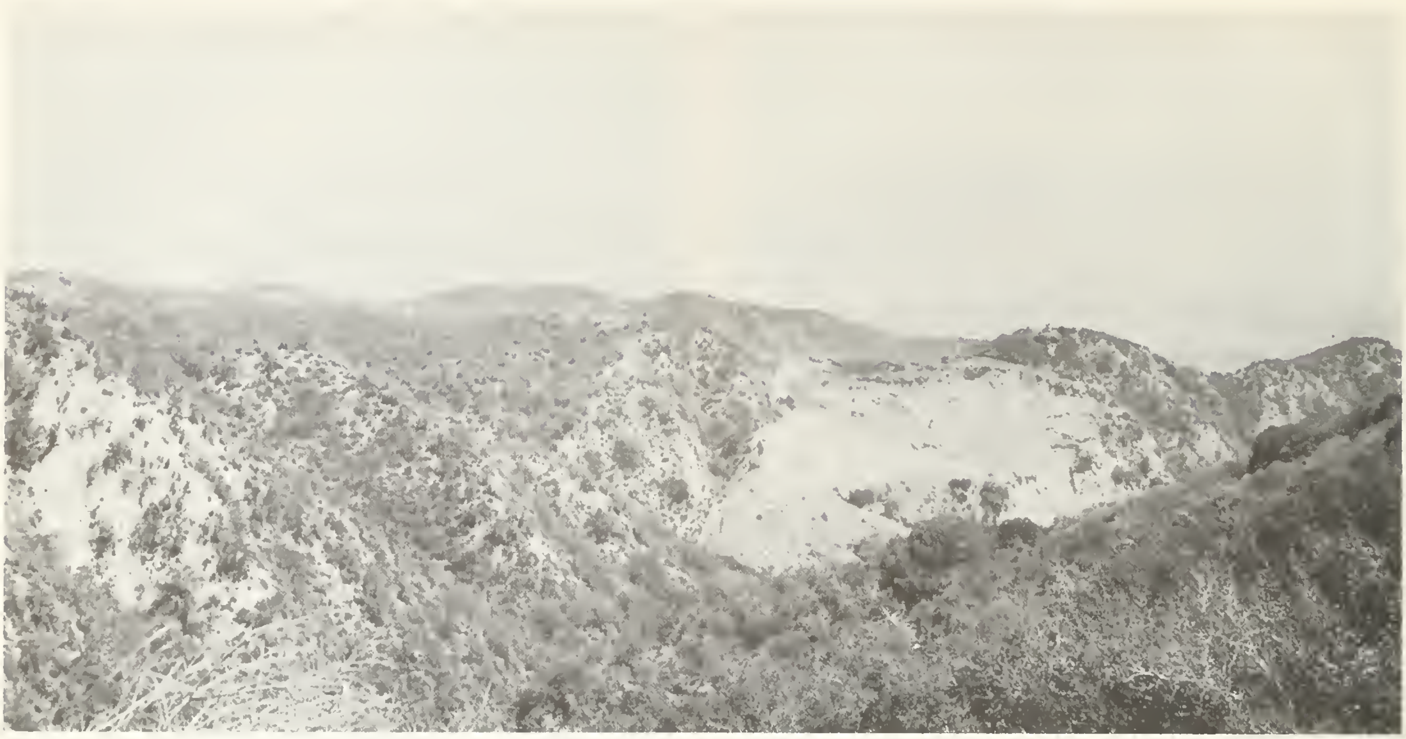

FIGURE 19. Sky Ranch Clay Company mine, east pit, north side of Wardlow Canyon. Quarry exposes clay shale of the Ladd formation, undifferentiated (Upper Cretaceous). Typical brush covered terrain of the Sky Ranch Clay Company mine area. Observer faces northeast.

pit and along the north side of Wardlow Canyon. The east pit furnished from 10 to 20 thousand tons of clay shale each year for several years, but has been inactive since about 1956. The west pit (figure 16) which is developed in an Upper Cretaceous clay shale zone along the north side of Wardlow Canyon, is about 500 feet wide, the loading face is about 20 feet high, and the shale has been mined to depths ranging from 5 to 10 feet over a strike length of about 1,500 feet. This pit was opened early in 1956, and in 1957 was the principal source of clay shale used by the Tillotson Refractories Company, Corona, discussed elsewhere in this report.

Paleocene clays appear to have little areal extent beyond the present limits of the Susie and McClintock quarries and reserves appear to be small. Large areas of Upper Cretaceous clay shale provide many hundreds of thousands of tons of reserves of red-burning clay shale, but probably only a part of the shale will prove suitable as a constituent for the manufacture of common clay products because of sandy and limy zones and gypsum veinlets.

Before 1956, the shale was mined with a combination Caterpillar-bulldozer-ripper which pushed the material into small wooden or steel chute-bunkers (figure 10) for loading into small trucks for transport to the Tillotson Refractories Company in Corona. Since early 1956, mining has been with a Caterpillar D-4 combination bulldozer-ripper (figure 17) which has loosened and moved the shale to a stockpile. From here a caterpillar No. 933 Traxcavator skip loader has loaded the shale on a 4-yard dump truck (figure 18). Two men do the mining, one operates the bulldozer-ripper and the other loads the dump truck and hauls the shale to Tillotson Refractories Company. Hard limy concretions which are locally intercalated in the shale, are removed by hand sorting at the mine.

Thomas Clay Deposit, East Pit. Location: NW¼ sec. 33, T. 3 S., R. 7 W., S.B.M. (projected), about 3 miles southwest of Corona, along the east side of the major west branch of Wardlow Wash. Ownership: Charles A. Thomas, P. O. Box 518, Corona, California, owns this property as part of the 500-acre La Sierra Stock Ranch; approximately 23 acres are leased to Gladding, McBean and Company, 2901 Los Feliz Boulevard, Los Angeles 39, California, who have sublet mining rights to the east pit area to Joe Deleo, Jr., clay supplier and mining contractor, 1233 Garretson, Corona, as operator.

In 1951 Joe Deleo, Jr., began prospecting activities which led to the discovery of the clay deposit on the Thomas property. The clay-bearing area subsequently was leased to Gladding, McBean and Company and Mr. Deleo began mining clay as a sublessee during 1953. A small production of only a few thousand tons each year has been maintained with some increase in production during 1956. Mr. Deleo supplies red-burning clay shale to several manufacturers of common clay products in the Metropolitan Los Angeles area. These manufacturers include the Atlas Sewer Pipe Company, Whittier, and the Jordan Tile Manufacturing Company, Corona.

The red-burning clay shale is obtained from a fissile marine claystone of the Paleocene Silverado formation. The claystone is buff to light gray in color and contains hard, limy concretionary zones. The claystone has an average strike of about N. 70° W. and dips vertically or steeply eastward. The clay zone being explored, including the adjoining west pit, has an exposed width of nearly 500 feet and an exposed strike length of about 1,000 feet. It is enclosed by, and may grade both laterally and along the flanks into, sandstone and cobble conglomerate.

Development consists of bulldozer cuts and benches, that have formed a sloping quarry face about 200 feet high and as much as 300 feet wide. The clay shale is stripped and mined intermittently by means of a combination tractor bulldozer-ripper which stockpiles loose material at the foot of the face. There a vertical face 50 feet high is being cut (figure 20) where the clay is loaded by a $1\frac{1}{2}$ cubic yard Lorain power shovel into 12-yard semitrailer dump trucks for transport to the several manufacturers. Irregularly distributed limy concretions are removed at the mine by hand sorting.

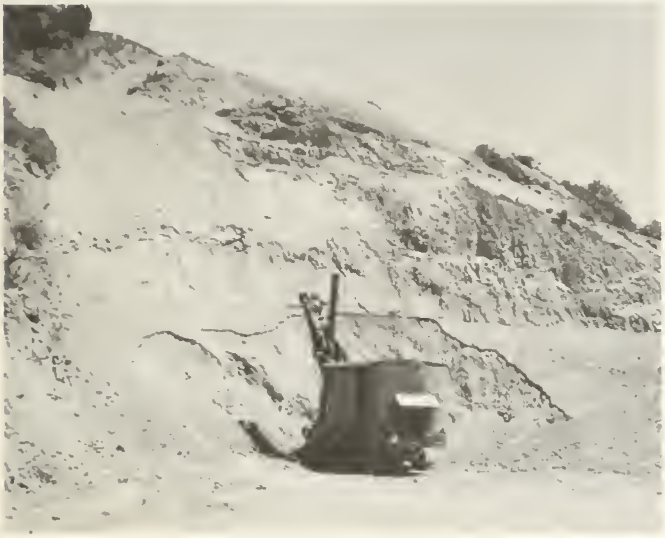

Figure 20. Thomas clay deposit, east pit (operated by Joe Deleo, Jr.). Fissile claystone of the Silverado formation (Paleocene) is mined by a ripper-bulldozer which piles loosened material from hill above at foot of sloping quarry face. Loosened material is loaded by the $1\frac{1}{2}$ cubic yard power shovel into dump trucks for transport to several manufacturers of common clay products. Observer faces southeast.

Thomas Clay Deposit, West Pit. Location: NW$\frac{1}{4}$ sec. 33, T. 3 S., R. 7 W., S.B.M. (projected), about 3 miles southwest of Corona, along the west side of the major west branch of Wardlow Wash. Ownership: Charles A. Thomas, P. O. Box 518, Corona, California, owns this property as part of the 500-acre La Sierra Stock Ranch; approximately 23 acres are leased to Gladding, McBean and Company, 2901 Los Feliz Boulevard, Los Angeles 39, California. Mining rights to part of the property are sublet to Joe Deleo, Jr., Corona, who operates the adjoining east pit, across the canyon.

Gladding, McBean and Company began development of this property in 1954. Extensive sampling, including core drilling of the clay shale, was done during 1955. The drilling is reported to have indicated several million tons of reserves. This material would probably be suitable as a constituent for red-burning common clay products. The production consists of a few hundred tons utilized for plant tests, and in October 1956 several thousand tons of clay shale remained stockpiled in the canyon between the west and east pits.

The deposit is on strike with the east pit across the canyon and is an extension of the same deposit. Excellent Paleocene marine fossils have been found (locality 29, pl. 1) in the west pit. Here sufficient cuts have been made to show that the nearly vertical clay shale and siltstone contain intercalated cobble conglomerate and sandstone. These appear to lens out abruptly both along the strike and from side to side. The workings expose a thickness of about 400 feet of continuous clay shale.

The property is developed by open cuts and benches on several levels. Mining has been done with bulldozer and ripper. Intermittent development work is continuing.

*Tillotson Refractories Company**. Location: 1150 West 6th Street (State Highway 71), Corona, SW $\frac{1}{4}$ sec. 26, T. 3 S., R. 7 W., S.B.M. (projected), in Corona North quadrangle. Ownership: Tillotson Refractories Company, 1150 West 6th Street, Corona. Clifford Tillotson owns and manages the operation and Gerritt Poelstra is superintendent.

Tillotson Refractories Company began operations in 1941 with the manufacture of insulating fire brick from clay purchased from the Alberhill Coal and Clay Company. In 1945, Mr. Tillotson began utilizing clay shales, from his Sky Ranch clay mine, in the manufacture of vitrified clay sewer pipe. Since then this has been the only product manufactured.

Raw materials used include (1) Upper Cretaceous clay shale (locally designated "Wardlow shale") from the Sky Ranch Clay Company (already described in this report); (2) red mottled clay of the Paleocene Silverado formation and mined at the Harrington clay pit 9 miles distant to the southeast on the east side of Temescal Wash and north of Dawson Canyon, and (3) "ball clay" (a plastic, refractory, sedimentary clay which is principally kaolinite and other aluminum silicates) of the Paleocene Silverado formation supplied by the Elsinore Clay Company from pits 2 miles north of Elsinore on State Highway 74.

In this modern plant (figure 21) the raw mix is made from a mixture of about 65 percent clay shale, 20 percent red mottled clay, and 15 percent "ball clay". Sewer pipe is formed by a combination pug mill, deairing and extruding machine. The pipe is then glazed and placed in drying rooms where it is dried by gas heat. From the drying rooms the pipe goes to "bee hive" periodic kilns for setting and burning, the final step in the process. The plant has been in continuous operation since 1941 and has grown steadily. There are now (1957) about 100 employees.

Vitrified sewer pipe is made in 4-, 6-, and 8-inch sizes and is mostly sold locally, but also reaches market areas as far distant as San Diego and Arizona.

Coal

Small quantities of lignitic coal are reported to have been mined near the mouths of Eagle and Main Street (Gypsum) Canyons, from a small canyon east of Joseph Canyon, and from the vicinity of the McKnight clay mine between Hagador and Mabey Canyons. Considerable carbonaceous material is scattered irregularly through nonmarine sandstones and soft clay shales, gyp-

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* Acquired by Pacific Clay Products, 1255 West Fourth Street, Los Angeles, California, on September 1, 1957. Operation continued without immediate major changes as Pacific Clay Products Corona Plant.

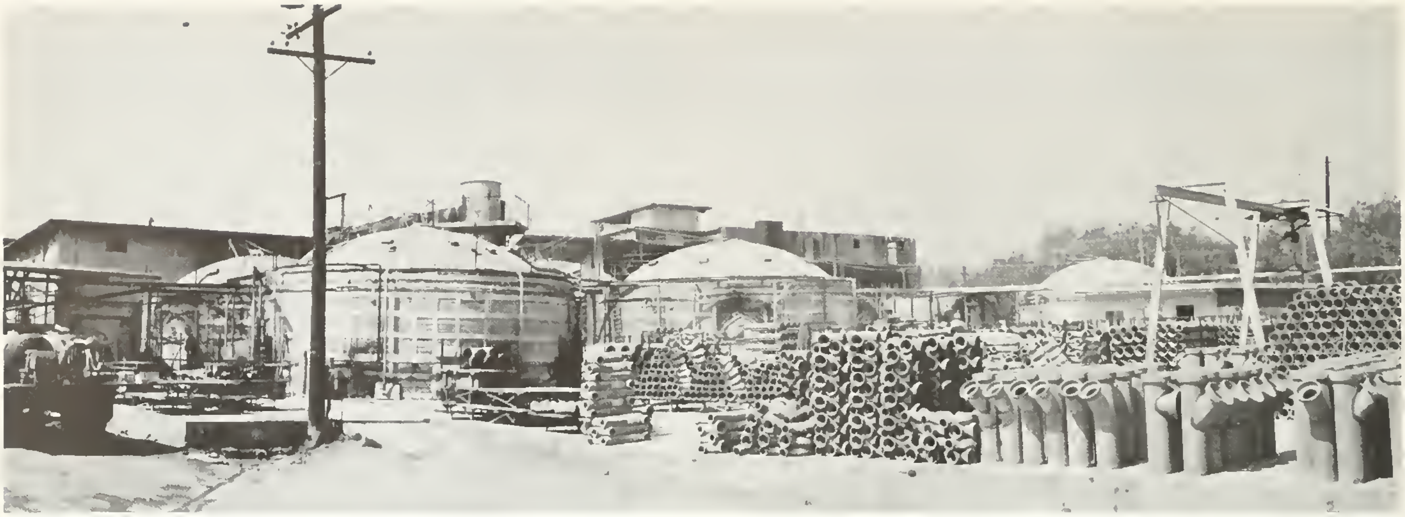

FIGURE 21. Clay pipe manufacturing plant of Tillotson Refractories Company, Corona. Raw material is ground, pugged and extruded to form clay pipe in building in background. Also in this building the pipe is glazed and dried by gas heat. The pipe then goes to periodic "beehive" kilns (center) for firing. Finished pipe is stored in yard (right foreground) to await truck shipment to users. Observer faces southwest.

siferous in places, of the Paleocene Silverado formation. Where mined, the coal is in small lenses or pockets closely associated with the economic clay zones of the Silverado formation.

Goodyear (1888, p. 505) described an active coal prospect about 4 miles southwest of Corona which may have been on or near the area of the McKnight clay mine where coal seams are still exposed in the old workings. He reported that a bed of soft coal, ranging from 3 inches to 4 feet in thickness and very irregular in quality, was exposed by an adit 60 feet in length from which a winze had been sunk about 170 feet deep.

Later, Tucker (1921, p. 325) reported the existence of a coal seam 4 feet wide on the Hoag Ranch in the vicinity of Joseph Canyon. Minor amounts of coal, not being utilized, are presently exposed in the active open pit workings of the Sky Ranch Clay Company mine (Susie claim) just north of Mabey Canyon. Recent (1956) drilling in lower Bedford Canyon near Highway 71 is reported to have encountered a lignitic coal zone 12 feet in thickness.

Production of coal in the Corona district has evidently been minor and was probably only for local use. All properties are idle at present and have been so for many years.

Dumortierite

Dumortierite is of value because of its excellent refractory qualities. According to Pampeyan (1952, pp. 53, 56, 57, 70) there are several occurrences of muscovite-dumortierite-tourmaline-quartz veins in coarse-grained phases of the Cajalco quartz monzonite near Temescal Wash. These occurrences were first described by Murphy (1930, pp. 79-80) and later mentioned by Larsen (1948, p. 106). The best-defined vein lies in the NE¼ sec. 5, T. 4 S., R. 6 W., S.B.M., near the railroad trestle. Another vein occurs in the NW¼ sec. 33, T. 3 S., R. 6 W., S.B.M., south of Home Gardens. In a third area, on the west side of Temescal Wash in the NW¼ sec. 9, T. 4 S., R. 6 W., S.B.M. (projected), dumortierite is disseminated through the quartz of the country rock. Pampeyan (1952, p. 53) estimated that none of these occurrences contained more than 2 percent of dumortierite. However, he described two richer occurrences east of the Temescal Wash area, one about one mile northwest of Cajalco Hill, the other about 1½ miles northeast of Cajalco Hill just northwest of the Cajalco spillway near the N¼ cor. sec. 1, T. 4 S., R. 6 W., S.B.M. These localities are on the Lake Mathews quadrangle. The locality northwest of Cajalco Hill is about 3 by 75 feet in plan and contains an average of about 20 percent dumortierite by volume.

Gypsum (Gypsite)

Gypsite, an earthy mixture of very small gypsum ($CaSO_4 \cdot 2H_2O$) crystals with clay and sand or other impurities, has been mined in an area that lies along the northeast flank of the Santa Ana Mountains and is about 4 miles south and southwest of the center of Corona. There a narrow, irregular belt, averaging about 500 feet in width but as much as 3000 feet wide containing rather low-grade gypsite, extends for about 3½ miles in a northwesterly direction between Joseph and Tin Mine Canyons. Although the gypsum content is only between 20 and 30 percent, the material carries enough iron and lime to make it of value as a soil conditioner (Ver Planck, 1952, p. 58).

During the first third of the twentieth century a considerable tonnage of this material was mined and mostly used locally as an agricultural mineral by orchardists of the district, several of whom had their own deposits. Mining has been carried on in Hagador Canyon, Main Street (Gypsum) Canyon and Eagle Canyon and here and there from the intervening ridges. Gypsum was mined, ground, and shipped from the Corona area as early as 1900, but most of the mining took place from 1909 to 1919 and from 1924 to 1934; there have been no shipments since that time although small amounts of material may have been sporadically mined for local use. During the period 1943-53 there was a minor renewal of activity. Several claims were taken by location and both the Eagle Canyon (Frazer) and Hagador Canyon deposits were taken under lease by several operators. Apparently little material was mined and in 1956 all of the properties were idle.

According to Ver Planck (1952, p. 58) those who have reported production of gypsite include the Soil Tone Company and E. R. E. Nonhof from Hagador Canyon; G. W. Lord from Gypsum (Main Street) Canyon; and the Amestoy Mineral Fertilizer Company, Natural Fertilizer Company, and Mineral Fertilizer Company from Eagle Canyon. These operations are indicated to have had production of less than 10,000 tons each. Early producers from unrecorded localities include El Cerrito Ranch, W. H. Jameson Company, and W. C. Barth (Merrill, 1919, p. 579). The latest production was in 1944 when Dr. Leon N. Katz, San Fernando, mined about 1,000 tons from the Frazer deposit in Eagle Canyon. The material was not sold, but used only for testing and experimental purposes (personal communication, Dr. Leon N. Katz, Dec. 16, 1956).

The host rock in the commercial gypsite belt, which is adjacent to the Elsinore fault zone, is a mass of dark greenish-gray hornblende andesite and dacite porphyries of the Jurassic (?) Santiago Peak volcanics, which have been mildly metamorphosed. In places the volcanic rocks are hard and have been cut by shear planes that strike northeast to northwest and dip steeply northwest or northeast, or are vertical, giving a blocky appearance. Elsewhere the volcanic rocks are soft and much weathered, but with relic shear planes. Along the shear planes are zones of hydrothermal alteration where the porphyries have been kaolinized and stained with limonite. Some fractures are filled with calcite and the volcanic rocks are pyrite-bearing. Closely spaced veinlets of fibrous gypsum cut the hydrothermally altered rock in all directions. Probably both the gypsum-bearing altered rock (gypsite) and the gypsum veinlets were mined.

Gypsite beds also occur locally in Upper Cretaceous and Paleocene clay shales which contain thin veinlets of gypsum along fractures and bedding planes. Calcium sulfate-bearing ground water being drawn upward by capillary action has deposited these small gypsum crystals. The gypsite beds in Cretaceous and Paleocene sedimentary rocks have not been mined and are believed to be too small for commercial development.

The commercial production of gypsite in the Corona area is hindered by several factors. For agricultural use, the only possible current economic outlet for this material, gypsite must generally contain more than 50 percent gypsum although grades as low as 30 percent are sometimes used under special conditions. Even so, the Corona deposits would require beneficiation. The commercial producer also must comply with the State Department of Agriculture regulations which require among other things that each lot or bag of gypsum must bear a tag stating the percentage of gypsum which cannot be more than 5 percent lower than the guarantee. In the Corona deposits, it would seemingly be difficult to maintain the purity of the product within the 5 percent limit, unless the producer used a very low figure. Finally, the grade and size of the Corona deposits do not appear to warrant the required investment in mining and milling equipment.

Small-scale development of some of the Corona gypsite deposits for local agricultural use might be possible. This would be particularly true if mine run material would be of special benefit to local citrus groves. However, even though the deposits are close to the citrus area, the cost of mining and handling might rule out such development in favor of commercial products which are both fertilizers and soil conditioners.

Eagle Canyon (Frazer) Gypsum Deposit. Location: Lots 1 and 2, SW¼ sec. 13; N½NW¼ sec. 24, T. 4 S., R. 7 W., S.B.M., along both sides of the mouth of Eagle Canyon, about 4 miles south of Corona. Ownership: T. A. and F. M. Frazer, 718 Howard Street, Corona, California own three unpatented placer claims: Eagle Group, Eagle Group No. 2 and Eagle Group No. 3, totaling about 150 acres.

In 1913 the Eagle Canyon deposit was mined for agricultural gypsum by the Amestoy Mineral Fertilizer Company which became the Natural Fertilizer Company in 1914 and continued the operation during 1914-15. After 1915, the company became the Mineral Fertilizer Company and operated in 1916 and 1917. The property apparently was then idle for several years. T. A. Frazer located some of the present claims in 1924 and others in 1939, but evidently did only discovery and assessment work. Dr. Leon N. Katz, 9837 Foothill Boulevard, San Fernando, California, held the property under lease in 1943-44 and T. A. Frazer located still another claim in 1953. The recorded production of gypsite from this deposit is small. Only during the years 1913-17 was the mined material marketed. During 1943-44 Dr. Katz mined a total of about 1,000 tons of gypsite from both sides of Eagle Canyon. This material was not sold, but was used only for testing and experimental purposes. There has been no production since 1944.

The gypsite occurs as a network of narrow, closely spaced, satin spar veinlets in zones of hydrothermally altered dacites and andesites of the Jurassic (?) Santiago Peak volcanics. The gypsiferous zones strike about N. 70° W. and lie along or near the Elsinore fault zone. An efflorescent deposit of yellowish-white aluminum sulphate occurs with the gypsum exposed in an open cut on the west side of Eagle Canyon. Minor amounts of gypsum are also present in clay shales of the Paleocene Silverado formation which rest in fault contact on the volcanic rocks. The mining apparently has been confined to the altered volcanic rocks, although the Silverado sedimentary rocks have been prospected. The gypsite-bearing belt, which is as much as 500 feet wide, occurs on both sides of Eagle Canyon and crops out sporadically for a lateral distance of nearly 1,500 feet across the ridge to the next small canyon to the west (Manning Canyon). Tucker and Sampson (1945, p. 168) report the gypsum content ranges from 15 to 25 percent, and is associated with iron and lime. However, most of the material has a gypsum content of only about 15 percent (personal communication, Dr. Leon Katz, Dec. 1956). Analysis of a composite sample taken by Dr. Katz, made by Ed Eisenhauer, Jr., Los Angeles, 1944 (see page 84).

Development consists of short adits, shallow open cuts, and prospect pits. On the west side of Eagle Canyon an adit is driven west 80 feet; about 200 feet south of this adit there is an open cut 70 feet in length; on the west side of Manning Canyon an adit has been driven west

Analysis of gypsite from Eagle Canyon

	Percent
Calcium oxide (CaO)	6.42
Magnesium oxide (MgO)	.09
Ferric oxide (Fe_2O_3)	3.69
Aluminum oxide (Al_2O_3)	6.41
Sodium oxide (Na_2O)	2.20
Potassium oxide (K_2O)	.16
Sulphuric anhydride (SO_3)	8.40
Phosphoric anhydride (P_2O_5)	.21
Silica (SiO_2)	61.62
Water (free) at 105°C	1.04
Combined water	9.36
Equivalent to calcium sulphate ($CaSO_4 \cdot H_2O$) (calculated)	16.22

100 feet (Tucker and Sampson 1945, p. 168). The most recent development was done in 1943-44 along the east side of Eagle Canyon and consisted of an adit driven southeast 20 feet and an open cut 60 feet in length and 15 feet in depth. At this time the lessee also installed a small crushing plant on the east side of Eagle Canyon. The plant consisted of a Williams hammer mill, with bucket elevator to a 10-ton storage bin. Gypsite mined from the open cut was delivered by truck to the crusher. Operations were suspended in 1945 because of high moisture content. Experiments with a dryer proved unsatisfactory and the lease was terminated. The mill was removed in the early 1950's.

Hagador Canyon Gypsum Deposit. Location: NW¼ sec. 15; S½SW¼ sec. 10; NE¼ sec. 16, T. 4 S., R. 7 W., S.B.M., along Hagador Canyon and the ridges on both sides of the canyon, about 4 miles southwest of Corona. Ownership: W. R. and Virginia Adams, 301 Fruit Street, Santa Ana, California, own two unpatented placer claims located in 1952: Farmer's Friend Nos. 1 and 2. In 1956 Orrin M. Pierce, 1607 North Flower Street, Santa Ana located two placer claims, Alpha and Omega in secs. 9, 10, 15, 16; and A. F. Bullard and William Redding, 1008 South Pacific Avenue, San Pedro also located two placer claims, Red Bull No. 2 (S½SW¼ sec. 10) and Red Bull No. 3 (N½NW¼ sec. 15).

The earliest recorded operation in the vicinity of Hagador Canyon was in 1910 when 275 tons of gypsite are reported to have been mined and shipped to citrus groves near Corona for use as a soil conditioner (Tucker and Sampson 1945, p. 169). According to Merrill (1919, p. 579) and Ver Planck (1952, p. 144) the first major operation was in 1915-16 when the Soil Tone Company, Corona, shipped a considerable tonnage from this area. Later the property was owned by the Amestoy Estate who leased to E. R. E. Nonhof, Corona, from 1924 to 1933, and the property was operated by Nonhof and G. R. Freeman in 1934. During the 1930's Nonhof and Freeman located eight placer claims known as the White Gypsum group in secs. 9, 10, and 16, T. 4 S., R. 7 W., S.B.M. The claims along Hagador Canyon were finally abandoned and in 1943 J. C. Middlesworth and C. E. McCorkill, Corona, relocated the deposit as Big Chief Nos. 1 and 2, Amador, and Morning Star Nos. 1 and 2 placer claims. In 1945 C. E. McCorkill located the Valley View placer. Victor Mishelle, Malibu Beach, held the property under lease in 1945 and later acquired part of the claims by quit claim deed. Some of these claims

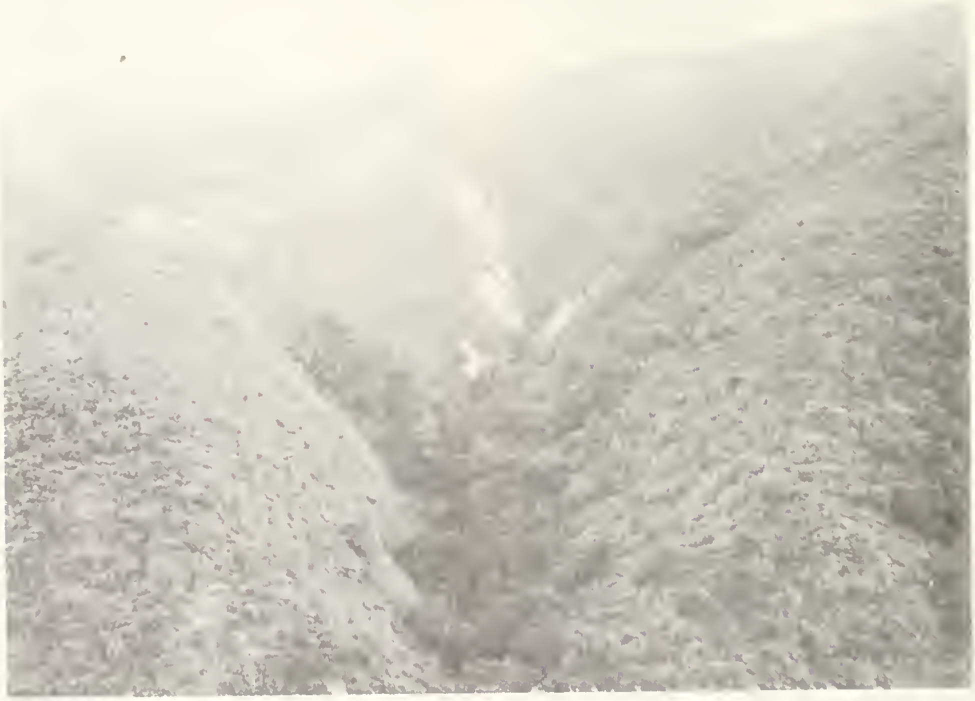

FIGURE 22. White Gypsum group deposit, south side of Tin Mine Canyon. Small amounts of gypsite were mined about 1923 from open cuts (light colored area in ravine, middle distance). Area is underlain by hydrothermally altered volcanic rock (Jurassic ? Santiago Peak volcanics) that contains veinlets of satin spar and gypsite. Dense brush cover is typical of the Corona gypsum-bearing area. Observer faces south.

apparently have been abandoned, in part, and were partly relocated by the present owners between 1952 and 1956. This property probably has been the principal source of agricultural gypsite in the Corona area. The output was sold as a soil conditioner to citrus growers in southwestern Riverside County.

The deposit was mined in 1915, 1916, 1924, and 1926-34; no production has been reported since 1934. Since 1934 only discovery work, sampling, experimenting with the material as a soil conditioner, and annual assessment work has been done.

The gypsum occurs in hydrothermally altered metavolcanic rocks of the Jurassic (?) Santiago Peak volcanics, and is similar to the Eagle Canyon deposit which is described elsewhere in this report. The gypsum-bearing zone strikes northwestward and lies along the southwest side of the Elsinore fault in rugged, brush-covered foothills of the Santa Ana Mountains. Along Hagador Canyon the gypsum-bearing zone is about 3,000 feet wide, but to the northwest narrows to about 1,500 feet on the south side of Tin Mine Canyon, where it apparently terminates. Tucker and Sampson (1945, p. 169) report the gypsite beds are about 200 to 300 feet in width and about 750 feet in length on the Big Chief claims which lie astride Hagador Canyon in secs. 10 and 16, but the principal exposure is on Big Chief No. 2, on the west side of the canyon. On the Morning Star Nos. 1 and 2 which join the Big Chief claims on the southeast and lie along the east side of Hagador Canyon, Tucker and Sampson (1945, p. 166) report an exposure of clay (probably altered volcanic rock along a shear zone) that contains 25 to 37 percent gypsum. This gypsum-bearing zone is about 600 feet wide and 1,500 feet long. On the Amador claim, which is southwest of the Big Chief claims and lies along the west branch of Hagador Canyon in the NE¼ sec. 16, is exposed a gypsite body several hundred feet thick.

Following is an analysis of samples by Smith-Emery Company (Tucker and Sampson 1945, p. 169):

		Percent
Big Chief No. 1	—calcium sulphate ($CaSO_4 \cdot 2H_2O$)	14.7
	phosphoric anhydride (P_2O_5)	0.05
Big Chief No. 2	—calcium sulphate ($CaSO_4 \cdot 2H_2O$)	18.5
	phosphoric anhydride (P_2O_5)	0.06

Samples taken by Tucker and Sampson (1945, p. 169) from Big Chief Nos. 1 and 2 and analyzed by Ed Eisenhauer, Jr., Los Angeles were as follows:

	Percent
Calcium oxide (CaO)	8.80
Magnesium oxide (MgO)	0.62
Ferric oxide (Fe_2O_3)	4.19
Aluminum oxide (Al_2O_3)	3.66
Sodium oxide (Na_2O)	2.89
Potassium oxide (K_2O)	0.30
Sulphuric anhydride (SO_3)	12.06
Loss in ignition	13.05
Gypsum ($CaSO_4 \cdot 2H_2O$) (calculated)	23.05

Development, reported by Tucker and Sampson (1945, p. 169) was as follows: shallow open cuts and an adit 20 feet in length on Big Chief No. 1; open cut 75 feet in width and 15 feet high on Morning Star Nos. 1 and 2 (the area from which the first shipment was made in 1910); and several large adits and open cuts and trenches on the Amador claim.

The largest tonnage came from the area of the Amador claim which was worked by E. R. E. Nonhof from 1927-34. Material from the open cut on the west side of Hagador Canyon was delivered by a jig back tram, 1,800 feet in length, to a crushing and screening plant in the canyon. This plant had a reported capacity of 40 tons per day. Collapsed remains of the tram line and plant remained on the property in 1956.

The open cuts and trenches are now caved and the principal adits are made inaccessible by standing water and caving. All of the claims are overgrown with brush so that the gypsite-bearing zones are very poorly exposed.

Main Street (Gypsum) Canyon Gypsum Deposit. Location: S½NE¼ sec. 15; N½S½ sec. 14, T. 4 S., R. 7 W., S.B.M., about 4 miles south of Corona along Main Street (Gypsum) Canyon and adjoining ridges. Ownership: Mrs. Josephine Middlesworth, 847 W. 9th Street, Corona, California, owns one unpatented placer claim (Morning Star) in the S½NE¼ sec. 15. Floyd N. Champion, et al., 3316 E. Anaheim Street, Long Beach 4, California, own five unpatented placer claims (Capitol Dome 1-5) covering about 75 acres in the NW¼SE¼ sec. 14, T. 4 S., R. 7 W., S.B.M.

The Main Street Canyon gypsum deposit probably was first worked by the Standard Fertilizing Company who mined 250 tons of gypsum in 1901 and about 150 tons before that date (Aubury, 1906, p. 286). George W. Lord controlled the property in 1906 and operated it intermittently and on a small scale from 1906 to 1917. G. R. Freeman became a partner in 1915 and continued to operate the deposit until 1937. J. C. Middlesworth located the Morning Star claim about 1944 and leased it to Dr. Leon Katz, San Fernando, California, for a short period. In 1945 the deposit was leased to Victor Mishelle, Malibu Beach, California, and since that time has been idle. The Capitol Dome group of claims, still held by location, were located prior to 1939 and include the eastern margin of the Main Street (Gypsum) Canyon deposit. This deposit had intermittent production of gypsite for agricultural use by citrus growers in the vicinity of Corona during a period before 1901 until 1935 (Ver Planck 1952, p. 126).

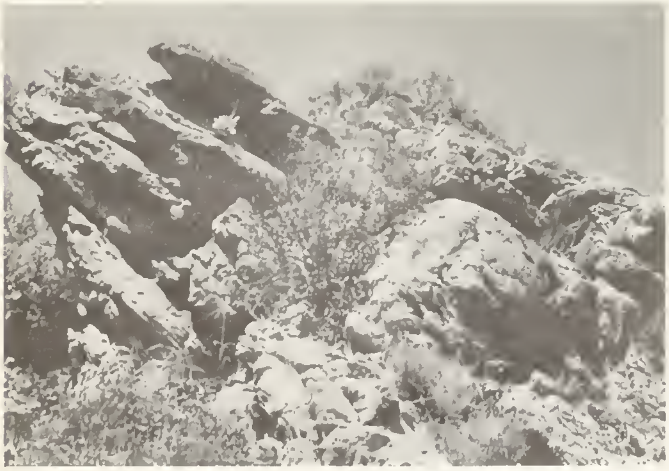

FIGURE 23. Ladd Canyon (Kroonen) limestone deposit. Dark gray crystalline limestone lens occurs in metagraywacke and argillite of the Triassic Bedford Canyon formation. This carbonate mass, the largest in the Corona South quadrangle, crops out on the west side of the East Fork of Ladd Canyon. Observer faces northwest.

The gypsum occurrence is similar to that of the Eagle Canyon deposit described elsewhere in this report. Satin spar veinlets occur in metamorphosed Jurassic (?) Santiago Peak volcanic rocks along the Elsinore fault zone and in brown shales of the adjacent Silverado formation. The main body of the deposit occurs along the west side of Main Street (Gypsum) Canyon and on the brush-covered ridge northwest toward Hagador Canyon. The gypsite-bearing zone is about 600 feet wide on the west margin of Main Street Canyon, but widens to nearly 1,500 feet on the ridge to the northwest. Tucker and Sampson (1945, p. 168) report that the exposed gypsite-bearing zone on the Morning Star claim was 700 feet in width. Several smaller exposures of gypsite lie on the east side of Main Street (Gypsum) Canyon.

Analysis of samples (Tucker and Sampson 1945, p. 168) made by Ed Eisenhauer, Jr., of Los Angeles is as follows:

	Percent
Calcium oxide (CaO)	11.05
Magnesium oxide (MgO)	0.81
Ferric oxide (Fe_2O_3)	5.32
Aluminum oxide (Al_2O_3)	4.43
Sodium oxide (Na_2O)	1.13
Potassium oxide (K_2O)	0.17
Sulphuric anhydride (SO_3)	16.31
Loss in ignition	13.35
Gypsum ($CaSO_4 \cdot 2H_2O$)	31.24

The deposit has been developed by adits, trenches, open cuts, and prospect pits. Dr. Katz did some sampling in 1944. Since 1945 only annual assessment work has been done; on the Capitol Dome group this has included cleaning out adits, clearing brush and some new open cuts.

Limestone

Dark-gray to black, fine-grained crystalline limestone lenses within the Bedford Canyon formation crop out at a number of places in the Corona South quadrangle. All but two of these occurrences are only a few feet wide and no more than several tens of feet long. In addition some of the fine-grained metasiltstones appear to contain about 15 percent calcite.

Two limestone bodies, one along the East Fork of Ladd Canyon and the other east of Bedford Motorway are of possible commercial interest. Chemical analyses indicate that these limestone bodies might be suitable for portland cement manufacture, but their small size apparently precludes this use. These occurrences are described elsewhere in this report.

Limestone was reported from this area as early as 1886, and a number of claims have been located. No record of production was found but small amounts of lime may have been burned before 1900 for local use as early day residents report the remains of a small lime kiln were found in Hagador Canyon in 1907. All claims were idle or abandoned for many years until 1958.

Ladd Canyon (Kroonen) Deposit. Location: SE¼ sec. 34, T. 4 S., R. 7 W., S.B.M. and NE¼ sec. 3, T. 5 S., R. 7 W., S.B.M. (projected), about 2½ miles northeast of Silverado post office along the west side of the East Fork of Ladd Canyon, Orange County. This is apparently the same limestone deposit that was reported to be in secs. 3 and 4, T. 5 S., R. 7 W., and sec. 33, T. 4 S., R. 7 W., S.B.M. in previous accounts (Tucker 1925, p. 68; Logan 1947, p. 261) but which could not be located here by the writer. Ownership: Great West Minerals and Materials Development Company, 8541 Calmada Avenue, Whittier, California, holds a total of 200 acres in 10 unpatented placer claims: Black Bird, Black Eagle, Black Hawk, Double D., Eureka, Mammoth, Mary, Santa Ana, Sunset, and Ultimo.

This deposit is said to have been discovered in 1886, but the first mining claims appear to have been located in 1915 when Leo Kroonen, Corona, California, located 10 claims. Mr. Kroonen did exploratory work through the 1930's but after that the property apparently was idle until relocated by the present owners in early 1958. This limestone was briefly described by Fairbanks (1893, pp. 115-116) and is probably the same body of limestone later mentioned by Smith (1898, p. 779).

In the 1930's these claims were accessible by several miles of dirt road leading northeast from Silverado Canyon along Ladd Canyon and then along the East Fork of Ladd Canyon. Much of this road is now completely washed out, and in some places is nearly impassable on foot. These claims are now best reached by taking the Ladd Canyon spring truck trail from the Main Divide truck trail and then proceeding down the creek about half a mile along the old Ladd Canyon foot trail, some traces of which still remain.

Dark gray, bluish-black, to black, very fine-grained crystalline limestone, which weathers light gray, occurs in bodies which crop out on the west slope of the East Fork of Ladd Canyon from the creek bed to the ridge top, 1,000 feet to the west. The limestone is fetid, cut by numerous veinlets of white, secondary calcite, and is moderately silicified. The limestone bodies appear to strike about N. 30°-35° W. and dip 45° to 60° to the northeast, but at one place in the southern part of the largest body the dip appears to be to the southwest, suggesting a possible anticlinal structure. The limestone bodies are narrow, discontinuous pods and stand out as resistant ledges or bold cliff faces (figure 23) in a series of Bedford Canyon formation metagraywackes, siltstones, shales, and argillites which are in part slaty. Some of the fine-grained, brown metasilts appear to contain about 15 percent calcite. The argillites and graywackes also have calcite cement.

The areas in the Ladd Canyon region shown as limestone on the geologic map (pl. 1) are mostly of carbonate rock but also contain intermixed metagraywackes, argillites, and shales. The largest continuous carbonate mass is about 100 to 200 feet in width and several hundred feet in strike (?) length. This mass is in a zone in which carbonate rocks are exposed over most of an area that averages about 500 feet wide and 1,000 feet long. In places, especially observable on weathered surfaces, this body appears to be a limestone breccia. Previous workers have collected ammonites and pelecypods from the Ladd Canyon area which indicate an Upper Triassic age for the limestone which is mapped (pl. 1) with the Bedford Canyon formation (p. 12, geologic text). In the largest carbonate lens, described above, the writer also found a few small ammonites and a number of pelecypods. This ammonite fauna is Jurassic in age (see footnote, geologic text, pp. 12-13).

Two samples, believed to be typical of the carbonate bodies, were collected by the writer from the SE¼SE¼ sec. 34, T. 4 S., R. 7 W., S.B.M. Sample No. 1 is from the largest carbonate body and No. 2 is from an elongate pod immediately south. Analyses of these samples, made by Abbot A. Hanks, Inc., San Francisco, in June 1956 were as follows:

Sample No.	Silica	Ferric oxide	Aluminum oxide	Calcium oxide	Magnesium oxide	Phosphorus pentoxide
1	8.28%	0.48%	1.87%	46.71%	2.32%	0.04%
2	3.27	0.26	0.39	50.81	2.12	0.01

The following analysis of a limestone from the same general area was made in the 1920's by F. W. Huber, University of California:

SiO_2	1.34%
CaO	51.45
Fe_2O_3 & Al_2O_3	1.95
MgO	1.86
Ignition loss	43.08
Undetermined	0.32

These few data indicate these carbonate rocks might be suitable for the manufacture of portland cement, although the magnesium oxide content is somewhat higher than is preferred by most users. This limestone probably would not be accepted as chemical grade or in the glass industry nor for other specialty uses which require a high chemical purity or extreme whiteness of processed material. No adequate estimate of reserves is possible because of a dense covering of brush in this area. However, the reserves probably are small and surely not sufficient to support a modern cement plant, unless the calcite-rich argillites could be utilized.

The carbonate bodies have been explored by a number of open cuts and several short adits, now mostly caved and heavily overgrown with brush. Trails leading to the larger outcrops were barely discernible when the property was visited in July 1956 and no recent work was observed. In May 1958 the owners repaired the Ladd Canyon spring truck trail and bulldozed a jeep trail from the spring to the deposit. So far as known, no commercial shipments of limestone have been made from this deposit.

Mineral Paint (Ocher)

Small amounts of mineral paint were produced from the Corona area during the period 1897-1910, but no production has been recorded since then (Tucker and Sampson 1945, p. 122, pl. 23). The deposits lie along the northeast margin of the Santa Ana Mountains in a northwest-trending belt extending from Main Street (Gypsum) Canyon to Hagador Canyon. They were developed as early as 1888 (Goodyear 1888, p. 505) and were mined in several operations. The principal activity was in the vicinity of Main Street Canyon.

This mineral paint was used as color pigments and was stated to be of very choice quality. About 20 colors were manufactured by the National Paint and Color Company of Corona (Aubury 1906, p. 339).

The mined material was ocher or ochery earth and apparently was obtained from the soft, fine-grained, reddish shales and yellow, red, and brown to purplish and blackish clays of the Silverado formation. The various colors of these rocks are determined largely by the amount and kind of iron present. According to Santmyers (1929, pp. 2-5) good grades of ocher should contain 20 or more percent iron oxide.

In 1944 the Kaiser Steel Corporation collected 107 samples from the Middlesworth clay deposit, northwest of Main Street Canyon and described elsewhere in this report. These samples yielded an average iron oxide content of 5.11 percent, and the highest iron oxide content was 16.43 percent (Draper, 1944). The results of that sampling indicate the ochery earths in the Corona area are too low in iron oxide to be of present commercial interest as a source of mineral paint.

Rock Products

In the Corona area, the quarrying of rock products is the principal mineral industry both in value and quantity. These products consist of the following categories, some of which are no longer produced: (1) broken and crushed stone used years ago for road base and riprap and currently for riprap; (2) decomposed "granite" used to surface roads; (3) dimension stone, including paving stone, building stone and monument stone; (4) roofing granules, produced by crushing hard intrusive rock; (5) sand and gravel for concrete aggregate; and (6) specialty sands, including sand used in foundries, sandblasting, and glass making. A listing of all rock producing operations in the Corona South quadrangle may be found in the tabulated list.

Broken and Crushed Stone

Broken and crushed stone, in blocks weighing as much as 10 tons, were produced prior to 1927 from the Temescal rock quarry which has also yielded thousands of tons of small (2- to 4-inch) crushed rock for macadamizing streets, and $\frac{1}{32}$- to 3-inch rock used in concrete aggregate. Three quarries, including the Temescal quarry, were opened near the mouth of Temescal Wash between 1888 and 1940; two have been nearly idle for many years, but since 1948 the Temescal quarry has been the source of large tonnages of roofing granules. So far as is known, no crushed coarse road base material has been produced from the Corona South quadrangle since the early 1930's.

In June 1957 production of broken stone was resumed when the new Temescal Canyon rock quarry was opened to supply 200,000 tons of riprap material for a levee along the Santa Ana River west of Riverside. This new quarry may continue as a source of broken rock of various sizes to the construction industry.

Jameson Quarry. Location: SW$\frac{1}{4}$ sec. 29, T. 3 S., R. 6 W., S.B.M., about one mile west of Home Gardens in low hills on the north side of State Highway 18. Ownership: Mrs. Mary C. Jameson, 316 East Olive Street, Corona, California, owns about 55 acres of patented ranch land.

The Jameson quarry was opened some years before 1924, as a small pit was then present. The quarry was idle from 1924 until about 1939 and was operated extensively during 1939-40 by J. B. Stringfellow, Riverside, California. This operation furnished a large tonnage of rubble, riprap, derrick stone, and toe rock, used to face Prado Dam and its abutments, which was constructed across the Santa Ana River narrows 4$\frac{1}{2}$ miles northwest of Corona under direction of the Corps of Engineers, U. S. Army. The property remained idle until about 1950 when Mr. Stringfellow quarried a small tonnage of rubble stone used to face the upstream abutments of the bridge on State Highway 18 across Temescal Creek, east of Corona. Since 1950 the quarry has

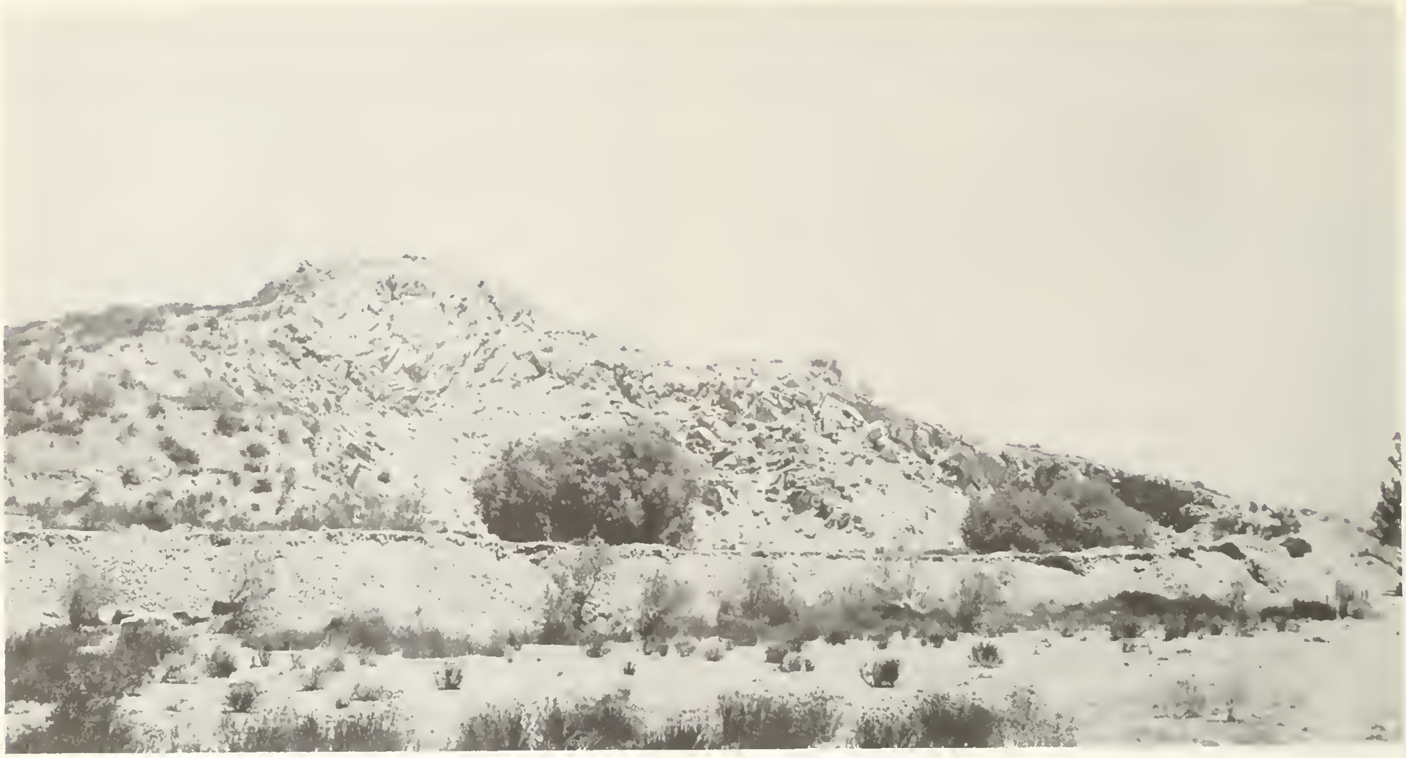

Figure 24. Jameson quarry, west of Home Gardens. Cretaceous micropegmatite granite has been obtained here intermittently since before the early 1920's, for use as small riprap and rubble. The most extensive operation was during 1939-40 when J. B. Stringfellow Construction Company quarried a large tonnage of riprap used to face Prado Dam. Observer faces east.

been inactive, except for the occasional gathering of small amounts of remaining loose material to be used locally as ornamental stone.

The quarry is in a pink, fine-grained, granular micropegmatite granite which may be approximately related in time to the Home Gardens quartz monzonite porphyry. The micropegmatite crops out over an area about 2 miles long and ranges from a quarter of a mile to three-quarters of a mile in width and lies mostly in the Corona North quadrangle. In hand specimen, the rock shows a few feldspar crystals in a very fine-grained crystalline mass of feldspar, quartz and minor hornblende. Larsen (1948, pp. 98-99) gives a detailed petrographic description together with a chemical analysis.

The rock occurs as reddish-brown, sheet-like masses and is well jointed so as to break into crude rectangular blocks. This sheet-like character is not shown by the other granitic rocks of the Corona area. The suitability of the rock for facing material is evidenced by the apparent lack of deterioration in the Prado Dam facing during 17 years. Probably little, if any, large riprap material could be developed from this quarry, but it contains a substantial reserve of material for small or medium sized rubble stone.

Rock was quarried on one level from a north-south bench (figure 24) about 200 feet long with the face 10 to 50 feet high, but potential backs are about 80 feet. No equipment remains on the property.

Sidebotham (Phillips) Quarry. Location: W½NW¼; NW¼SW¼ sec. 5, T. 4 S., R. 6 W., S.B.M., about 2 miles southeast of Corona, south of Temescal Wash and east of Compton siding. Ownership: William N. Guth, Chicago, Illinois, owns about 100 acres of patented land in section 5.

The Sidebotham quarry was opened in the middle 1930's to furnish rubble, riprap and track ballast for the A. T. & S. F. R.R. Co., who reported production during 1935-39. Local residents report that the quarry was owned by a Mr. Phillips and that the quarrying was done by the Sidebotham Rock Company. The major part of the output probably was used by the Santa Fe Railway Company to repair damage to their track beds caused by overflow of the Colorado River. Some material is said to have been used about 1938 to protect State Highway 18 from the Santa Ana River west of Green River Camp. The property was later acquired by the Staso Milling Company, 332 South Michigan Avenue, Chicago, Illinois, and, although inactive, was retained by them until 1957 when it was acquired by the present owner.

The rock exposed in the quarry area is an equi-granular to somewhat porphyritic, medium-grained granodiorite, a phase of the Corona hornblende granodiorite porphyry which typically contains about 45 percent plagioclase, 15 percent quartz, 10 percent orthoclase and 20 percent fine-grained groundmass with abundant mafic minerals. The rock is dark gray to blue-gray on weathered surfaces and dark greenish-gray on fresh surfaces. The granodiorite is hard, irregularly jointed, and breaks into large, blocky, generally unweathered masses. In thin sections of fresh specimens few microfractures are seen and the only observed alteration was a partial sericitization of the orthoclase. Tests on two samples from the Sidebotham quarry made about 1939 by the District

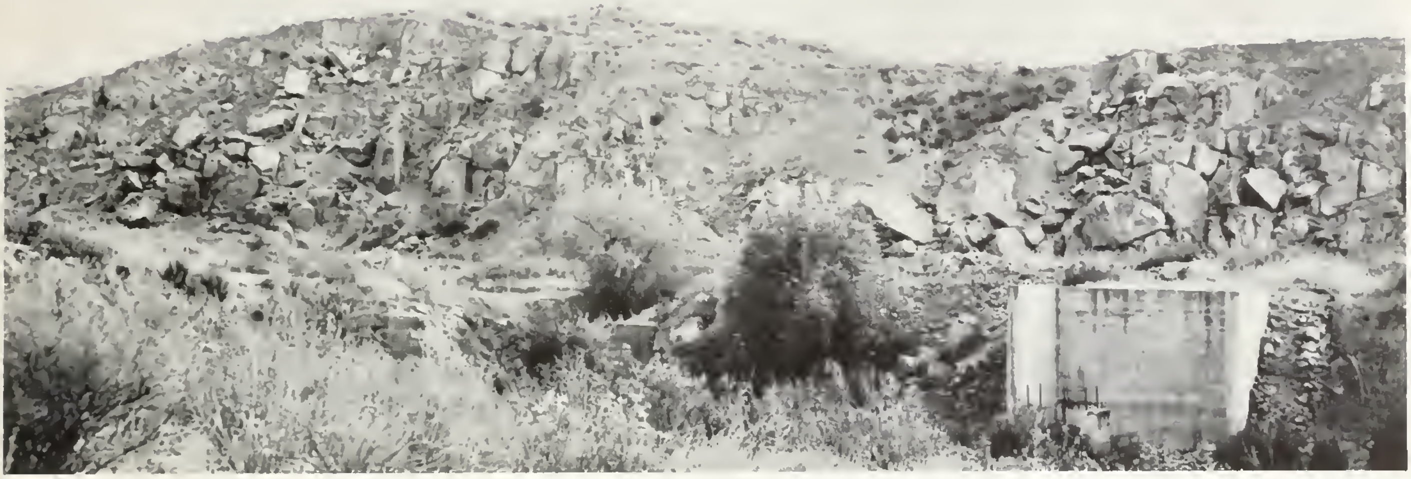

FIGURE 25. Sidebotham (Phillips) quarry, north pit. Jurassic or Cretaceous granodiorite (Corona hornblende granodiorite porphyry) was quarried here about 1935-39 for use as riprap and track ballast by the Santa Fe Railway Company. Crusher installation foundation remains in right foreground. Observer faces southwest.

Laboratory, Corps of Engineers, U. S. Army, showed the following:

Specific gravity	Absorption	L.A. Rattler, % loss at 500 rpm		
		Average	Maximum	Minimum
2.70	0.2	12.2	13.2	11.1

The L. A. Rattler test results, as well as the observed physical properties, indicate the granodiorite probably is sufficiently sound for use as riprap on levee slopes. However, the little-fractured nature of the rock may make the cost of quarrying prohibitively high. Substantial reserves are present as the granodiorite crops out over nearly the entire area of the property.

The rock has been removed from two quarries in gentle, low hills. The south quarry (NW¼SW¼ sec. 5) is roughly circular in plan and about 250 feet in diameter. It was worked from a single level with the face 10 to 40 feet high, but has potential backs of about 80 feet. The second quarry (figure 25) is about half a mile to the north (NW¼NW¼ sec. 5) and was opened on one level about 350 feet long in a southeast-northwest direction. The face is from 25 to 50 feet high with potential backs of about 120 feet.

No equipment remains, but concrete foundations mark the location of loading facilities. These quarries have been idle since 1939. Future plans of the present owner are unknown, but the proximity of residential areas makes future large-scale operation unlikely.

Temescal Canyon Rock Quarry. Location: SW¼ sec. 33, T. 3 S., R. 6 W.; NW¼ sec. 4, T. 4 S., R. 6 W., S.B.M., 1 mile south of Home Gardens along the east side of Temescal Wash near its northwest end. Ownership: Frank S. Spires, Corona, California, and Wesley Collins, Costa Mesa, California, each own a large acreage. In June 1957 the Temescal Rock Products Company, P. O. Box 364, Corona, California, held about 250 acres in secs. 4 and 33 under lease. Matich Brothers and Sundt Company Contractors, Colton, California, was the operator in September 1957.

The Temescal Canyon Rock quarry was first opened in May 1957 by the Temescal Rock Products Company to supply approximately 267,000 tons of stone for a levee being constructed along the Santa Ana River west of Riverside. The quarried product consists of facing stone, toe stone, and derrick stone in several sizes ranging from 1 pound to 4,500 pounds. This project, the Riverside Levees Flood Control Project, is under construction (September 1957) by the U.S. Army Corps of Engineers, Los Angeles District. After a small initial production, the quarry operation was taken over by the Matich and Sundt Company, in August 1957, who continued to supply stone to the levee project. In the future the Matich and Sundt Company expects to furnish rock, according to specification, to the construction industry. However, in April 1958 the Riverside County Board of Supervisors denied the Matich and Sundt Company's request for a permit to operate the rock quarry. Strong opposition to quarrying operations in the vicinity was registered by residents of the Home Gardens-Corona area.

The operation consists of two quarries, about 1,250 feet apart on the east side of Temescal Wash, in an equigranular to somewhat porphyritic phase of the Corona hornblende granodiorite porphyry, a medium-grained, dark-colored intrusive rock of Jurassic or Cretaceous age. The granodiorite is dark gray to blue-gray on weathered surfaces and gray to dark greenish-gray on fresh fractures and forms subrounded hills. Texture varies from medium-grained granular at the quarries to porphyritic with fine-grained crystalline groundmass elsewhere. The composition is that of a granodiorite and typical specimens contain about 45 percent plagioclase, 15 percent quartz, 10 percent orthoclase, and 20 percent fine-grained groundmass with abundant mafic minerals. Alteration minerals include sericite and chlorite.

In the north quarry is exposed only granodiorite porphyry, but in the south quarry is exposed a small mass, about 300 feet long and 25 to 50 feet wide, of Temescal Wash quartz latite porphyry which is surrounded by granodiorite. Several dikes of decomposed granitic material cut the granodiorite. The dikes are as much as 10 to 15 feet thick, where exposed in the quarry face, and probably are related to the Cretaceous Cajalco quartz monzonite. The quartz latite porphyry is blue-gray on weathered surfaces and dark blue-black on fresh fractures. In hand specimen the porphyry shows abundant phenocrysts of euhedral orthoclase and subhedral plagioclase and quartz, ranging from 1 to 6 millimeters in longest dimension, and smaller phenocrysts of hornblende, biotite, and magnetite. The nature of the groundmass cannot be determined in hand specimen, but microscopic examination shows it to be a mosaic of quartz, orthoclase, plagioclase, hornblende, and magnetite. The hornblende and biotite have partly altered to chlorite, whereas secondary sericite and chlorite occur as inclusions in the orthoclase phenocrysts.

In hand specimen both the granodiorite and quartz latite are hard and dense. Although microfractures are present they are largely confined to the feldspar phenocrysts. Alteration is confined to some sericitization of the orthoclase. In June 1957 the U. S. Army Engineer Division Laboratory, Corps of Engineers, Sausalito, California tested samples of the granodiorite and obtained the following data:

Weight lbs./cu. ft.	Apparent specific gravity	Specific gravity saturated, surface dry	Absorption	L.A. Rattler, % loss at 1000 rpm	
				Grade E	Grade F
169.7	2.721	2.712	0.19	19.2	19.7

The microscopic characteristics, together with the L.A. Rattler test, indicate this material is probably suitable for levee slope riprap. Although the rock is very hard and dense within individual blocks, its rather well-defined jointing and content of weathered dikes apparently supply good breakage qualities, and quarrying should be relatively easy. However, the weathered zones at times make blast hole drilling difficult. Large reserves are available, as the granodiorite crops out in a belt more than one mile long and about 1,000 feet in average width. The potential maximum backs are about 250 feet above the floor of Temescal Wash.

Temescal Rock Products Company had two quarries, one about 1,250 feet north of the other, under development in June 1957. These lie in the SW$\frac{1}{4}$ sec. 33. The rising topography along the east side of Temescal Wash provided a natural slope for the initial quarry face (figure 26) and this face was being steepened by blasting to form a face about 60 feet high. Blast holes were drilled by a Joy rotary-air-blast drill (figure 28), with capacity of 100 feet. The holes were 60 feet deep and arranged in

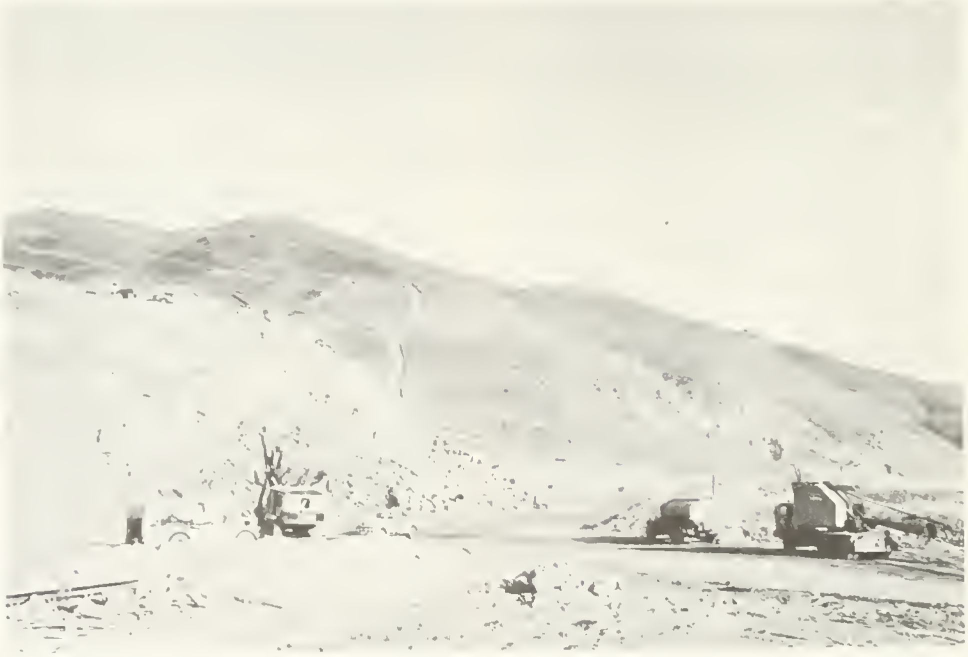

Figure 26. Temescal Canyon rock quarry of Matich and Sundt Company, eastside of Temescal Wash. Granodiorite (Corona hornblende granodiorite porphyry) of Jurassic or Cretaceous age was obtained from north quarry (left foreground) and south quarry (right middle ground) during 1957, for use in facing a levee along the Santa Ana River west of Riverside. Jurassic quartz latite (Temescal Wash quartz latite porphyry) was also obtained from the south quarry. Observer faces southeast.

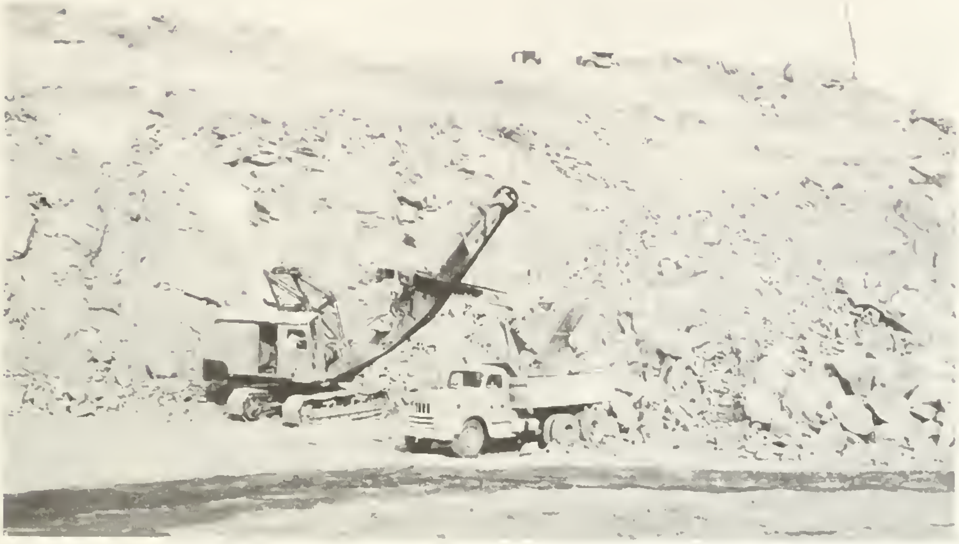

FIGURE 27. Loading blasted-down rock at north pit of Matich and Sundt Company's Temescal Canyon rock quarry. Vertical blast holes are drilled from above (rock drill and compressor, upper right). Six-wheel dump trucks transport the material to job site or to stockpile area in Temescal Wash where the rock is sized by means of bulldozers and secondary breaking is done with drop balls operated from truck-mounted cranes. Observer faces east.

two rows around the face. The rows were 10 feet apart (10-ft. burden) perpendicular to the quarry face, and the holes were 15 feet distant, parallel to the quarry face. After blasting, some secondary breaking was done with jackhammers (figure 28) and a drop ball operated from a small truck-mounted crane. Two Caterpillar D-8 bulldozers removed waste rock overburden and cleaned up the quarry floor.

Blasted-down rock was loaded into small Autocar cab over end-dump trucks, equipped with 6-yard quarry-type bodies, which transported the material a short distance to an inclined grizzly (figure 29). Material less than 2 inches in smallest dimension dropped through the grizzly and was removed by bulldozer, while the usable rock accumulated in a stockpile at the foot of the grizzly where a No. 109 Northwest power shovel with 2½-cubic-yard dipper bucket loaded the material on trucks for transport to the job site. Rock in the quarry was loaded by another Northwest power shovel, either for direct transport to the job or for the grizzly. A Caterpillar No. 977 Traxcavator skip loader with rock bucket was used to clean up the quarry floor and to load trucks or to stockpile blasted-down rock.

The method of rock handling was somewhat modified when Matich Brothers assumed the quarrying operations. Drilling is done (September 1957) with two rotary air-blast drills. Blasted-down rock is loaded on six-wheel end-dump trucks at the face by Northwest power shovels with 2½ cubic yard dipper buckets (figs. 27, 30). The material is transported by trucks about half a mile to a stockpile area in Temescal Wash. Here the rock is spread out and sized by means of bulldozers and the necessary secondary breaking is done with two truck-mounted cranes with drop balls. Caterpillar No. 977 Traxcavator skip loaders with rock buckets load finished rock on dump trucks for transport to the job site near Riverside.

Decomposed Granite

Two places in the Corona South quadrangle have been mined for "decomposed granite" ("DG"), probably for local use in surfacing unpaved roads. A small quarry was

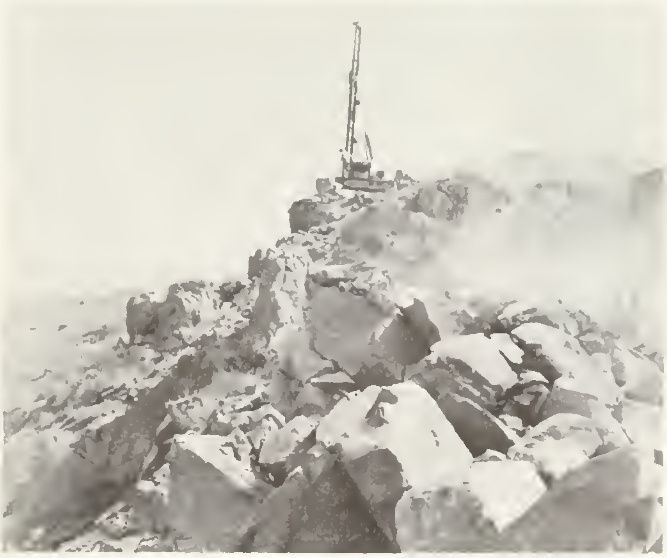

FIGURE 28. Blast hole drilling with Joy rotary-air-blast drill (top center) and secondary breaking with jackhammer (middle right) at Temescal Canyon rock quarry, north pit. Observer faces northeast.

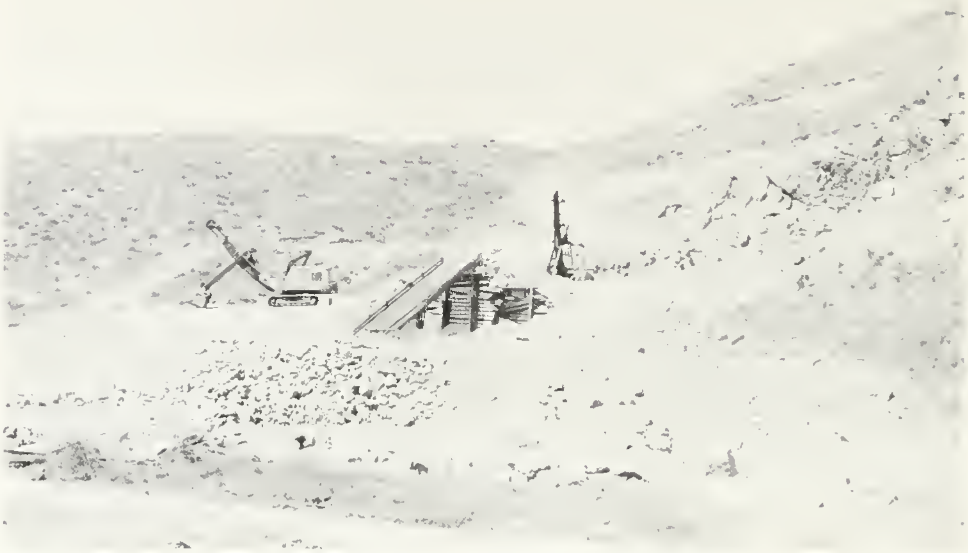

Figure 29. Temescal Canyon rock quarry, south pit. During initial quarry development in June 1957 by the Temescal Rock Products Company blasted-down rock from the quarry (right middle distance) was loaded by power shovels on small dump trucks which transported the rock a short distance to a grizzly (center). Rock under specification size dropped through the grizzly and was removed as waste by bulldozer. Useable rock accumulated in a stockpile (center foreground) at the foot of the grizzly where power shovels loaded the material on trucks for transport to the job site. Observer faces northeast.

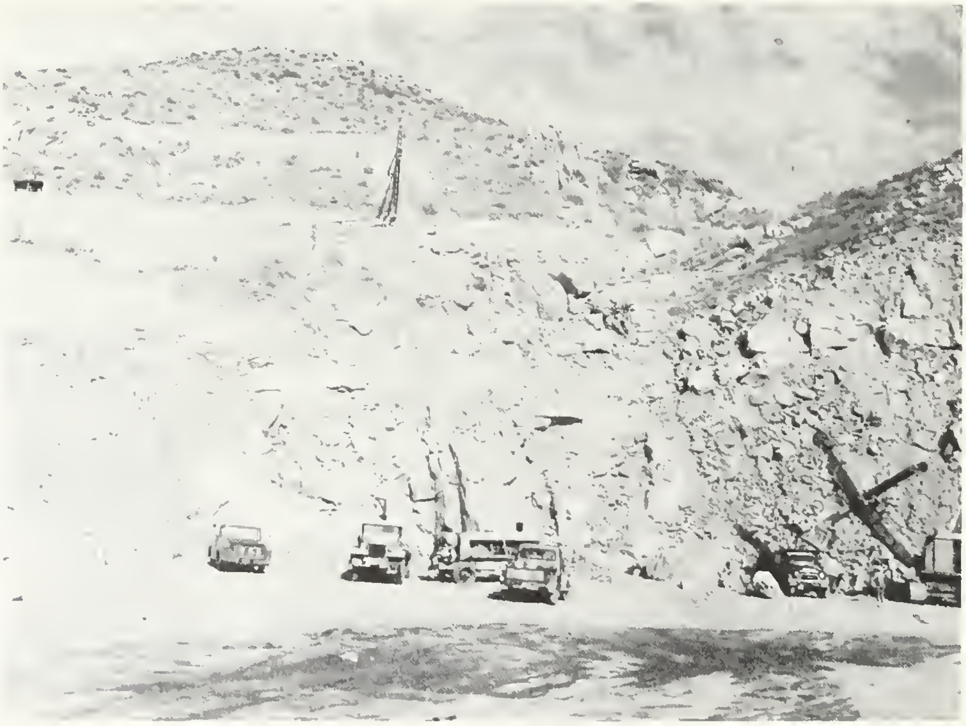

Figure 30. Matich and Sundt Company's Temescal Canyon quarry, south pit, September 1957. Most of the rock quarried here is granodiorite but the ravine (right center) contains a small body of quartz latite porphyry. Blast holes are drilled above (center) while blasted-down rock is loaded below (lower right) for transport to sizing area. Observer faces east.

opened years ago in weathered quartz monzonite northeast of El Cerrito Village. During 1956 a few tons of weathered quartz diorite apparently was mined northwest of Anderson Canyon. The total tonnage of decomposed material furnished from the quadrangle has been small.

Dimension Stone

Dimension stone, which includes blocks of natural stone which are generally cut or broken to definite shapes or sizes, was quarried in the Corona region during the first quarter of the twentieth century. Three classes of dimension stone were produced: Belgian paving blocks, monument stone, and building stone. Little or none has been produced since the 1920's.

Most, if not all, of the production came from an area 3 to 4 miles northeast of Corona in secs. 8, 16, and 17, T. 3 S., R. 6 W., S.B.M. (Merrill, 1919, pp. 584-585). This region is several miles north of the Corona South quadrangle and is underlain by a group of plutonic rocks which represent the southern California batholith. A great deal of this material is available, but the fresh unweathered rock is rather inaccessible. However, some of the production, especially the monument stone, may have come from rock quarries in the northeast corner of the Corona South quadrangle.

Several claims for building stone recently have been located in secs. 28 and 33, T. 4 S., R. 7 W., S.B.M. (see tabulated list). These claims are located in platy quartzite, serpentine, and blocky silica-carbonate rock, and apparently remained unworked in 1957.

Roofing Granules

Large tonnages of roofing granules have been produced since 1948 from the Temescal rock quarry. This is by far the largest mining operation in the Corona South quadrangle to date.

Temescal Rock Quarry. Location: S½ sec. 4, T. 4 S., R. 6 W., S.B.M. (projected), on the east side of Temescal Canyon (formerly locally termed Hoag's Canyon), about 4 miles southeast of Corona. Ownership: Minnesota Mining and Manufacturing Company, 900 Bush Avenue, St. Paul, Minnesota (P.O. Box 815, Corona, California), owns patented land in secs. 4, 5 and 9, T. 4 S., R. 6 W., S.B.M., totaling about 1,100 acres. R. E. Gundlach is regional manager and G. J. La Venture is plant superintendent.

The Temescal rock quarry was opened about 1888 to furnish rock for macadamizing streets in Los Angeles and nearby towns. According to Goodyear (1888, p. 506) an extensive crushing works with a capacity of about 200 tons of crushed rock per day was being erected in 1888. This site may also be the location of the San Jacinto Tin Mining Corporation's projected "6.5 mile" tunnel which was intended to crosscut the Cajalco tin veins. This tunnel, begun about 1890, was soon abandoned. By 1914 the quarry was owned and operated by the Temescal Rock Company whose plant had a capacity of 1,500 to 2,000 tons of crushed rock products per day.

By 1914 an inclined tramway had also been installed to load blocks, as much as 10 tons in weight, for riprap and seawall construction. The quarry, whose floor was 180 feet above the bottom of Temescal Canyon, extended along the hillside south of the crushing plant. After blasting, broken rock was loaded with a steam shovel into electric dump cars for rail transport to the nearby primary crusher. Finished products of five size grades were stored in bins, awaiting rail shipment (Merrill, 1919, pp. 586-587).

About 1920 the quarry was purchased by the Blue Diamond Materials Company, Los Angeles, which used the "porphyry" for building aggregate and road metal. Mining was by the tunnel or coyote system and brought down from 600,000 to 1,500,000 tons of rocks in each blast; 45 to 125 tons of powder were used per charge. The production of the crushing plant had been increased to nearly 5,000 tons per day (two shifts) by 1924 and the bench then being quarried was approximately 350 feet high and 1,200 feet long. Crushed rock products in six sizes, ranging from $\frac{1}{32}$-inch to 3-inch, were produced and used mainly for concrete aggregate, particularly in highway and building construction (Allen, 1923, pp. 887-890; Tucker, 1924, p. 45). The Blue Diamond Company continued operation of the quarry until 1927, when the plant was destroyed by fire. Except for small amounts of 3-inch crushed rock, sold occasionally to local aggregate producers for use in special road jobs (personal communication, C. H. Gray, Sr., Dec. 1956), the property remained idle until 1947 when it was reopened by the Minnesota Mining and Manufacturing Company to produce roofing granules. It has been in continuous operation since.

The quarry is in Temescal Wash quartz latite porphyry, a fine-grained, dark-colored, intrusive rock of probable Jurassic age. The quartz latite is blue-gray on weathered surfaces and blue-black to gray on fresh fractures and forms rugged, steep cliffs. The rock, which has a fresh appearance, consists of abundant white feldspar and quartz phenocrysts in a gray microcrystalline

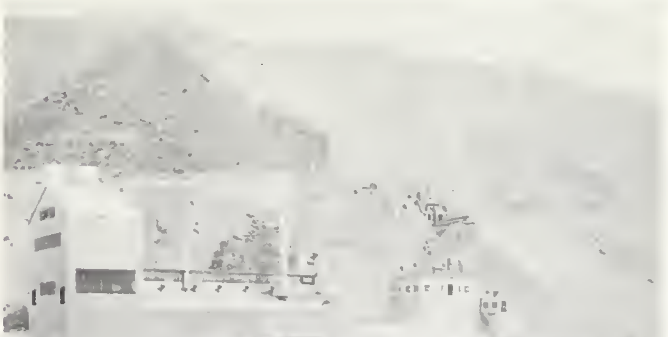

FIGURE 31. Minnesota Mining and Manufacturing Company operation in Temescal Canyon. Plant (foreground) includes coloring building and warehouse at left, crushing and screening building (center), and offices at far right. Raw material stockpile behind plant (right middle distance). Primary crusher is at quarry floor level, above stockpile and about 200 feet above plant. After crushing the rock is colored with subvitreous ceramic glazes for use as granules on prepared and built-up roofing. Observer faces southeast. *Photograph courtesy of Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.*

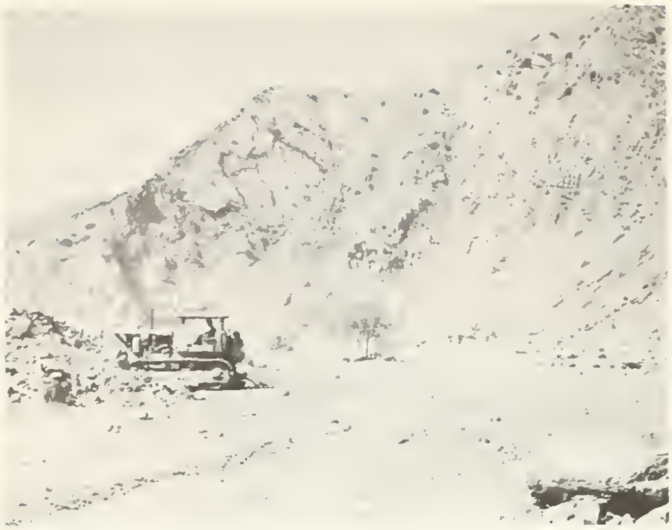

Figure 32. Temescal rock quarry of the Minnesota Mining and Manufacturing Company. Jurassic (?) Temescal Wash quartz latite porphyry is blasted down by large-scale coyote-hole blasting methods. At face (right center) Lorain 2½ cubic yard diesel power shovel loading 12-ton Euclid end-dump truck which transports material to primary crusher. Secondary breaking of blasted down rock is done (left center) with crane-mounted drop ball while in left foreground Caterpillar D-8 bulldozer cleans up quarry floor. Observer faces northeast. *Photograph courtesy of Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.*

groundmass. The phenocrysts are mainly of plagioclase whereas the groundmass is mainly quartz and orthoclase in about equal amounts. The rock ranges from dacite to quartz latite in composition, an effect of small differences in the feldspar ratio. The rock has good breakage qualities and is very hard. Locally it has often been referred to as "dark porphyry" or hard "trap" rock. Reserves of the "porphyry" are virtually inexhaustible.

The Minnesota Mining and Manufacturing Company became interested in the Temescal quartz latite porphyry as early as 1937. Samples were processed in the company's operating Wausau, Wisconsin, roofing granule manufacturing plant and the resulting granules were subjected to weathering tests under all types of climatic extremes. Five years of such tests proved the rock to be satisfactory and the company then acquired an 800 acre tract along Temescal Canyon. The huge quarry had been idle since 1927, but the previous operator had left 150,000 tons of blasted-down rock at the foot of a steep 400-foot quarry face.

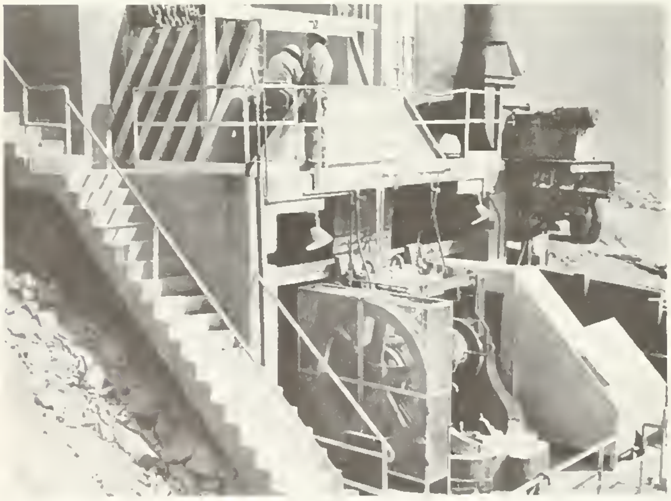

Figure 33. Primary jaw crusher at Temescal rock quarry of Minnesota Mining and Manufacturing Company. The crusher is set at 4 inches and produces rock for the raw material surge pile at a rate of 150 tons per hour. Observer faces southeast toward quarry floor at right. *Photograph courtesy of Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.*

The present operator began a new quarry road in April 1947, and the construction of a steel and concrete plant was completed a year later. The first granules were processed in June 1948. The function of the plant is twofold; first, the material is crushed and screened into sizes suitable for various types of roofing granules and second, artificial colors are applied and bonded to the granules. Initial capacity of the plant was about 100,000 tons of granules each year. This has been increased several fold.

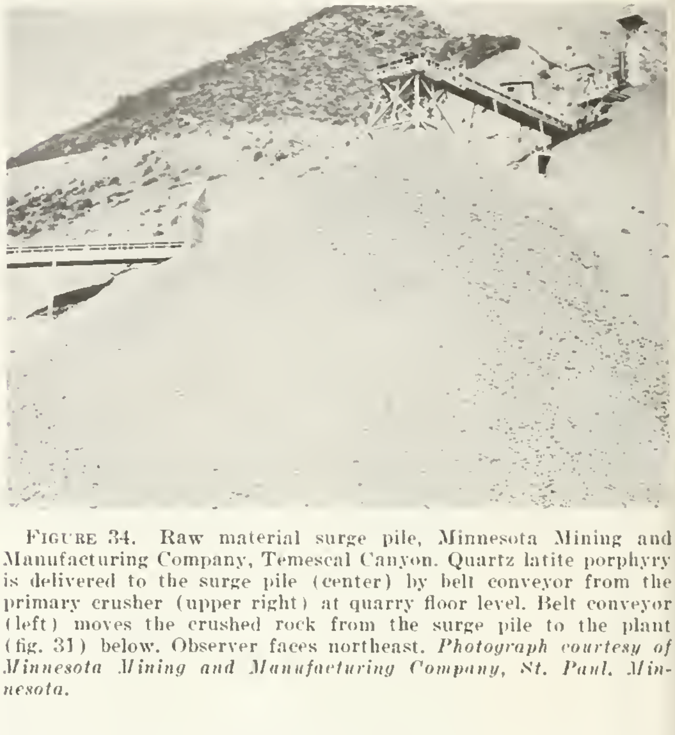

Figure 34. Raw material surge pile, Minnesota Mining and Manufacturing Company, Temescal Canyon. Quartz latite porphyry is delivered to the surge pile (center) by belt conveyor from the primary crusher (upper right) at quarry floor level. Belt conveyor (left) moves the crushed rock from the surge pile to the plant (fig. 31) below. Observer faces northeast. *Photograph courtesy of Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.*

During the first year, the plant operation drew upon the 150,000 tons on the quarry floor. The "coyote-hole" method of blasting has since been used; two shots in 1949 and 1950 brought down 500 and 325 thousand tons respectively in the first step of the process. The existing quarry face is steep and nearly 400 feet high and the company has continued to widen the bench, which is about 1,000 feet long, on that face. In the spring of 1956 the length of the quarry, on the same bench, was extended about 900 feet to the south. This southward quarry extension, however, was only exploratory and the original north part of the quarry continues in 1958 to be the chief source of rock. As quarrying progresses the face probably will be benched or worked on two levels.

After initial blasting, secondary drilling is done with jackhammers to reduce the larger pieces to about 3 feet maximum dimension, or secondary breaking is done by crane-mounted drop ball. A Caterpillar D-8 tractor-bulldozer is used to clean the quarry floor and to aid the operation of a Lorain 2½-cubic-yard diesel shovel and a 2½-cubic-yard Bucyrus Erie electric shovel by means of which four 12-ton Euclid end-dump trucks are loaded (figure 32). The material is trucked a short distance to the primary jaw crusher (figure 33, 34), located at quarry floor level about 200 feet above the processing plant (figure 31). From the primary crusher a belt conveyor takes the material to a surge pile (fig. 34). From there another belt conveyor moves the material to the plant.

The rock is crushed in four stages which successively employ the primary jaw crusher; standard cone; short-head cone; and roll crusher. The fines are removed in intermediate stages. The screening system is complex and includes a final rescreening, after glazing, of the finished product to remove tramp oversize and the last traces of fines and dust. The coloring is done in batches; raw granules, plus oxides, chemicals, and other coloring ingredients are proportioned and put through a mixing cycle. After mixing, the particles, now uniformly coated go to a rotary kiln where the pigment is permanently bonded on the granules as a sub-vitreous ceramic-type glaze. The finished granules are stored in steel silos from which they are loaded into box cars. A small proportion of the output is packaged in paper bags.

Careful quality control is maintained by a laboratory inspection of samples taken during various stages. Full provision has been made for elimination and removal of dust. The plant has a daily capacity of more than 500 tons and is the largest of its kind on the Pacific Coast. About 85 persons are employed.

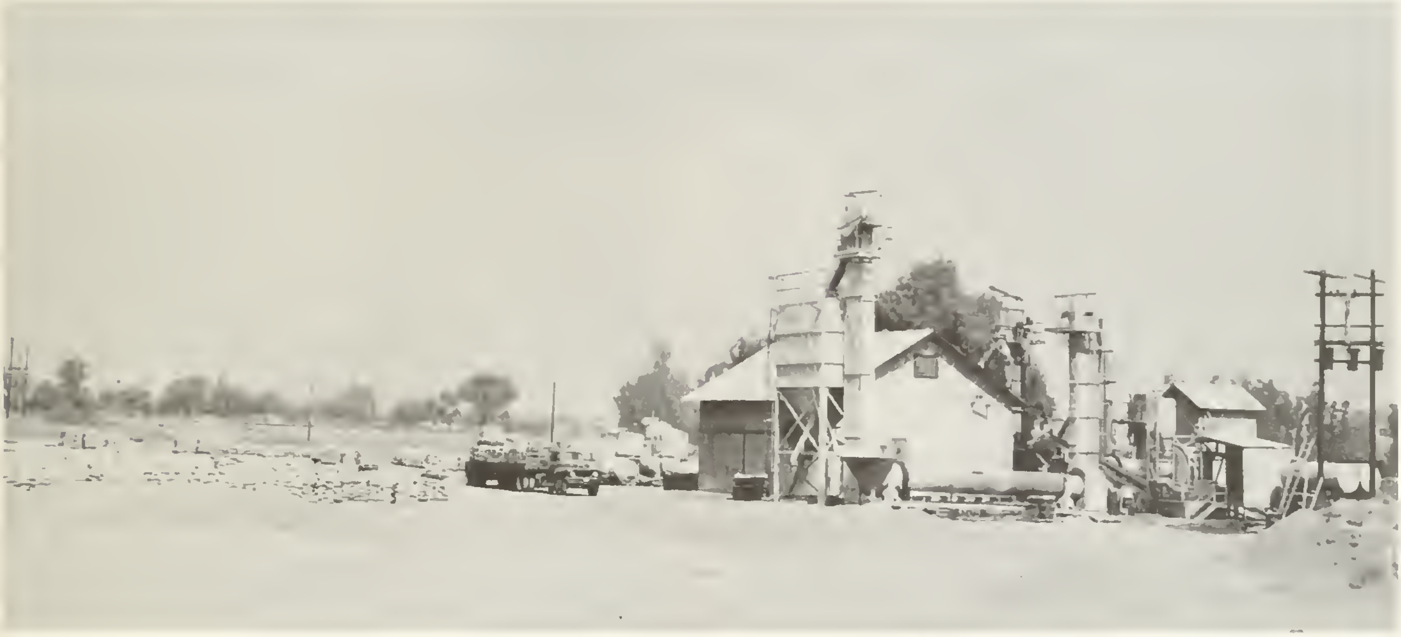

Figure 35. Roofing granule coloring and sacking operation of Minnesota Mining and Manufacturing Company at Corona. Here crushed and sized rock, delivered by trucks from the Temescal Canyon operation, receives a subvitreous ceramic glaze. From raw material stockpile the rock goes to coloring operation (right) and then to rotary kilns (right center) where the color is bonded to the rock. Finished granules are elevated to storage bins and packaged in paper bags, which are stored on pallets (left) awaiting truck shipment to users. Granules are produced in two sizes and 10 colors for use on built-up roofing. Observer faces northwest.

Granules are produced in a variety of sizes and a wide range of colors. Pastel shades of red, green, and blue are some of the most popular. The trade term for the colored granules is "ceramic-color stone". The major output is fine-grained material in the range 10 to 35 mesh used for processed roofing; additional but smaller amounts of coarse granules in two sizes (¼- to ½-inch; 1½- to 3-inch) and 10 colors are produced for built-up roofing. The granules for built-up roofing are colored at a small plant on East Third Street, Corona, north of the city park (figure 35). Crushed material is delivered by dump truck to the Corona plant from the Temescal Canyon quarry and sizing plant, about 5 miles distant. Coloring ingredients are added to the raw granules and the material goes to a rotary kiln where the pigment is bonded on the granules. The finished granules are sacked in paper bags. Two identical kiln circuits are used, one for each of the granule sizes produced.

The products are supplied to roofing manufacturers throughout the west coast region and are shipped to points as far distant as Vancouver, British Columbia. Fine-sized material is also marketed as an impact abrasive.

Reject material from the crushing operations recently has been put to a new by-product use. During 1956, Pacific Clay Products began using small amounts of this reject (—28 mesh) in sewer pipe manufacture at their Los Nietos plant. Gladding, McBean and Company also use this material in the manufacture of sewer pipe at their nearby Corona plant, which was placed in operation in January 1958. This material is reported to improve the shrinkage and drying qualities of the pipe. About 80,000 tons of the reject are produced each year.

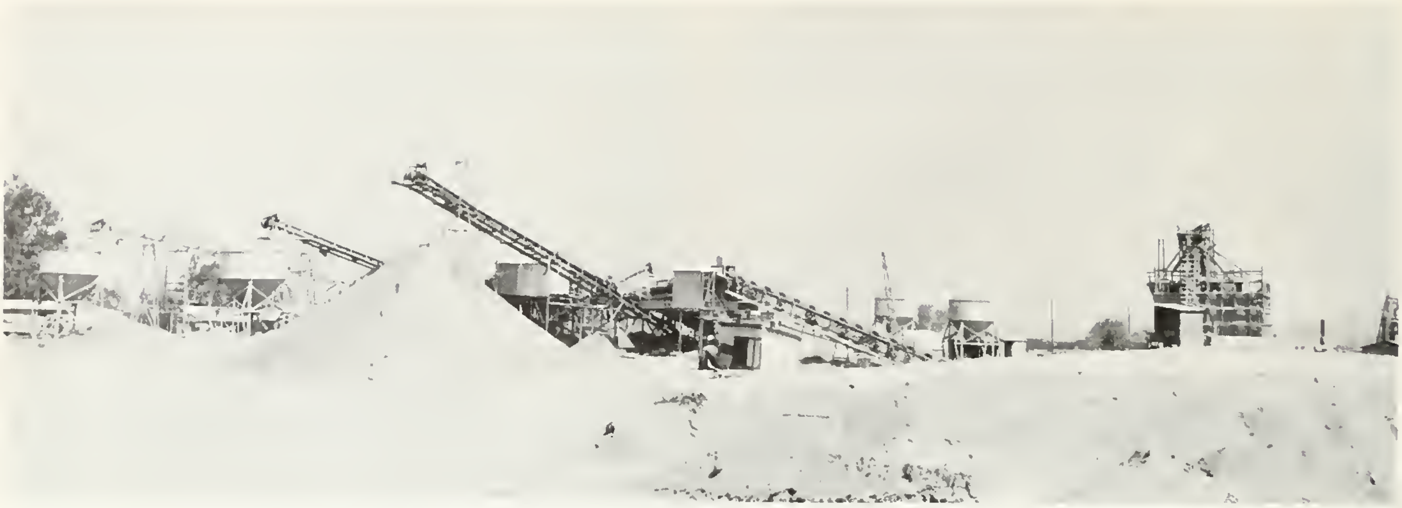

FIGURE 36. Corona sand and gravel plant of the Transit Mixed Concrete Company in lower Temescal Wash, east of Corona. This medium-sized plant processes stream bed material from lower Temescal Wash. Observer faces northwest.

Sand and Gravel

Sand and gravel, so far as known, have been produced commercially only in small amounts from the Corona South quadrangle. However, two areas immediately north of the quadrangle have been significant sources.

Sand and gravel was mined during 1939-40 from the lower part of Wardlow Wash in sec. 28, T. 3 S., R. 7 W., S.B.M. (projected), in the southwest corner of the Corona North quadrangle, just south of State Highway 18. This material was used to make hot asphalt and concrete for the construction of the nearby highway in 1939, and also for concrete aggregate used in Prado Dam in 1940. The property has been idle many years. In August 1957 the Torrance Sand and Gravel Products Company, Torrance, California, announced their intention of opening the deposit and constructing a processing plant which was expected to be in operation in 1958. In October 1958, however, the deposit remained inactive.

The Transit Mixed Concrete Company (see tabulated list) operates a medium-sized sand and gravel quarry and plant (figure 36) one mile east of Corona in secs. 29 and 30, T. 3 S., R. 6 W., S.B.M. (projected), at the mouth of Temescal Wash. The plant and most of the mine area are in the Corona North quadrangle but a small part of the mined-out portion of the pit extends across the north edge of the Corona South quadrangle. Their operations include the production of rock, sand, and gravel and the manufacture of regular and lightweight building blocks, pipe, and other concrete products. This property has been in operation for many years and was formerly operated by Kuster and Waterbury.

Two small shallow gravel pits east of the Corona City dump, in sec. 32, T. 3 S., R. 6 W., S.B.M. (projected), were operated on a small scale during 1937-39 by the Corona Rock Company (see tabulated list). These pits are 10 to 15 feet deep and expose a dirty, silty sand with very little rock.

Specialty Sands

Glass Sand

Glass sand was produced from the Corona area as early as 1905 (Aubury, 1906, p. 375). The exact location of the deposit, which was operated by the Corona Pressed Brick Company, is not known, but it probably was either the Nonhof molding sand deposit or one of several "feldspar" deposits along Wardlow Wash.

Silica sand, now entirely used in glass manufacture, has been continuously produced from the Corona sand deposit since the 1920's. The sand is quarried from nearly flat-lying beds of the lower part of the Paleocene Silverado formation which are exposed in only a few places east of Bedford Canyon about 6 miles southeast of Corona.

Logs from several oil wells drilled between Bedford and McBribe Canyons indicate that this sand unit ranges from about 100 to possibly more than 300 feet in thickness, and may underlie at least 2 square miles in that area. It is covered, however, by younger sedimentary units that range in thickness from about 200 to nearly 1,000 feet. The overburden thickens southward. The Silverado sands are probably down-dropped by several vertical faults several thousand feet north of McBribe Canyon, and in some places between these faults and the Elsinore fault the Silverado formation may be completely cut out by faulting.

Considerable bulldozer trenching and some drilling by the Ottawa Silica Company, Box 437, Ottawa, Illinois, in search of new silica sand deposits was done in 1956. This work was confined to an area along the Elsinore fault zone and included both sides of McBribe Canyon which lies between Bedford and Brown Canyons. The drill holes were put down in a narrow fault sliver of Paleocene Silverado formation sandstone northwest of McBribe Canyon and are reported to have encountered useable glass sand (personal communication, R. G. Crosley). Most of the area examined, however, is underlain by grayish-green sands, clayey sands and conglomerates, that probably are upper Eocene to lower Miocene in age and were mapped as the Vaqueros and Sespe formations, undifferentiated. These sands are not the same as those currently being mined for glass sand at the Corona sand deposit and if correctly assigned to the Vaqueros-Sespe, are younger. The exploration work apparently did not encounter a satisfactory reserve of useable glass sand.

In April 1957, the landowners of the Coronita Ranch sand deposit (described elsewhere in this report) which is along the northeast margin of Bedford Wash, put down 10 exploratory drill holes. Several of the holes, at shallow depths, penetrated Silverado formation sandstone similar to that exposed in the Owens-Illinois Glass Company pit which adjoins the property on the east. Other holes bottomed in older alluvium at 90 feet, indicating that the sand deposit is not of uniform thickness and has been channeled and filled with stream debris. During 1958 the Del Monte Properties Company, P. O. Box 150, Pacific Grove, California, did extensive drilling and sampling on the Coronita Ranch. This exploration was not completed at the time of writing (Oct. 1958) but preliminary results indicate a probable commercial glass sand deposit.

Foundry and Sandblasting Sand

Foundry ("molding") sand has been obtained in small quantities from several localities in the Corona South quadrangle. These deposits apparently are in secs. 10 and 11, T. 4 S., R. 7 W., S.B.M., about 4 miles southwest of Corona. The sands are lenses in the Paleocene Silverado formation and were worked intermittently from 1917 to 1924. The material was used in Los Angeles for iron casting, apparently as molding sand. Foundry sand and material for sandblasting formerly were produced, by the Weisel Industrial Sand Company, from the Corona sand deposit now operated for glass sand by the Owens-Illinois Glass Company.

Corona Silica Sand Deposit (Owens-Illinois Glass Company, P. J. Weisel Industrial Sand Company). Location: NE¼ sec. 21; SE¼ sec. 16, T. 4 S., R. 6 W., S.B.M., 6 road miles southeast of Corona on State Highway 71. Ownership: Louis A. Weisel, et al., La Habra, California, own about 550 acres of patented land in secs. 15, 16, 21 and 22, T. 4 S., R. 6 W., S.B.M. The Owens-Illinois Glass Company, 330 Sansome Street, San Francisco, California (P.O. Box 298, Corona, California), holds under lease about 140 acres in secs. 16 and 21. P. J. Oertel is plant manager.

The Corona silica sand deposit is the oldest continuously operated source of silica sand in southern California and continues to be the principal source. The deposit, which lies athwart State Highway 71 in Temescal Valley, was opened and developed in the early 1920's by the P. J. Weisel Industrial Sand Company. The plant was operated by this company until 1945 when it and the deposit were taken over by Owens-Illinois Glass Company. A new and much larger plant was erected in 1947 near the site of the old plant which was dismantled. The new plant began production in 1948 and has since been in continuous operation.

The sand is obtained from a quartz-rich facies of the Paleocene Silverado formation. The deposit consists of gently dipping, thinly bedded and locally cross-bedded white sandstone. Where exposed in the active pit (1957) west of the highway and in the old quarry face east of the highway, the usable sandstone is about 120 feet thick; but well data (figure 45) indicate it may be nearly 300 feet thick a short distance west of the present pit. In the mine area the Silverado formation is exposed over an irregularly shaped rectangular area about 2,000 feet wide and 3,000 feet long. The sandstone is covered by overburden ranging from several feet of older alluvium in low-lying areas, to 20 feet or more of Quaternary terrace gravels, which cap the deposit unconformably on several low hilltops. The sandstone is weakly cemented by clay and contains lenses of gray or grayish-green silt and sandy clay. Along the northwest margin of the pit west of the highway, the intercalated sandy clay beds strike N. 40° to 50° W. and dip 8° to 10° to the southwest.

The sandstone is coarse-grained to pebbly. The sand size particles are almost wholly angular to subangular quartz grains, and the pebbles, which are rounded, are of quartz and feldspar. The sandstone contains abundant pearly gray flakes of anauxite and black to greenish black or grayish-green mica (biotite and muscovite) which commonly give the sand a distinctive schistose appearance. Minerals present in minor proportions include, in order of decreasing abundance: feldspar, magnetite-ilmenite, epidote, zircon, tourmaline, and hornblende. About 30 to 40 percent of the deposit is clay, silt and fine sand (−200 mesh); 60 to 70 percent is sand and small pebble sized (+200 mesh to ¼-inch); and generally less than 10 percent is large pebbles (+¼-inch to ½-inch).

A marked increase in the clay-sand ratio occurs below the usable sandstone at a depth of about 120 feet in the pit west of the highway; this apparently marks the lower limit of glass sand. Stripping of the upper part of the deposit in the north extension of the pit has shown the presence of lenses and pods of micaceous silt and sandy clay in a greater ratio than in the south part, thus requiring the selective removal of considerable waste material. Drilling in the pit area west of the highway has penetrated clay beneath the anauxite-bearing glass sand (Stauffer, 1946, map), and water wells on the property bottomed in feldspathic biotite diorite at 100 feet (well no. 1, plate 1) and biotite quartz monzonite at 325 feet (well no. 2, plate 1).

The Corona silica sand deposit is an unusual quartz-rich facies in the lower part of the Paleocene Silverado formation and is apparently nonmarine. Deposits of silica sand and clay occur elsewhere in the Silverado formation 10 to 15 miles to the south, southwest along the southwestern flank of the Santa Ana Mountains, mainly near Trabuco Canyon, Orange County, but are not altogether comparable in composition with the Corona deposit. None of the Silverado sandstone exposed elsewhere in the Corona area appears to correlate precisely in composition with the Corona deposit, but the arkosic sandstone which overlies the sedimentary clay zone in many of the clay pits probably correlates stratigraphically with the Corona deposit.

The property was first developed in the early 1920's by means of a quarry in sec. 16, T. 4 S., R. 6 W., S.B.M., on the east side of Highway 71. By 1928 a washing and screening plant, on the east side of the highway and of 50 tons daily capacity, was in operation. Material mined from quarries and open pits east of the highway was delivered to the plant by dragline scrapers. The products included glass sand, foundry sand and sandblasting sand. Ten men were employed (Tucker and Sampson, 1929, p. 504). By 1944, the principal quarry was 600

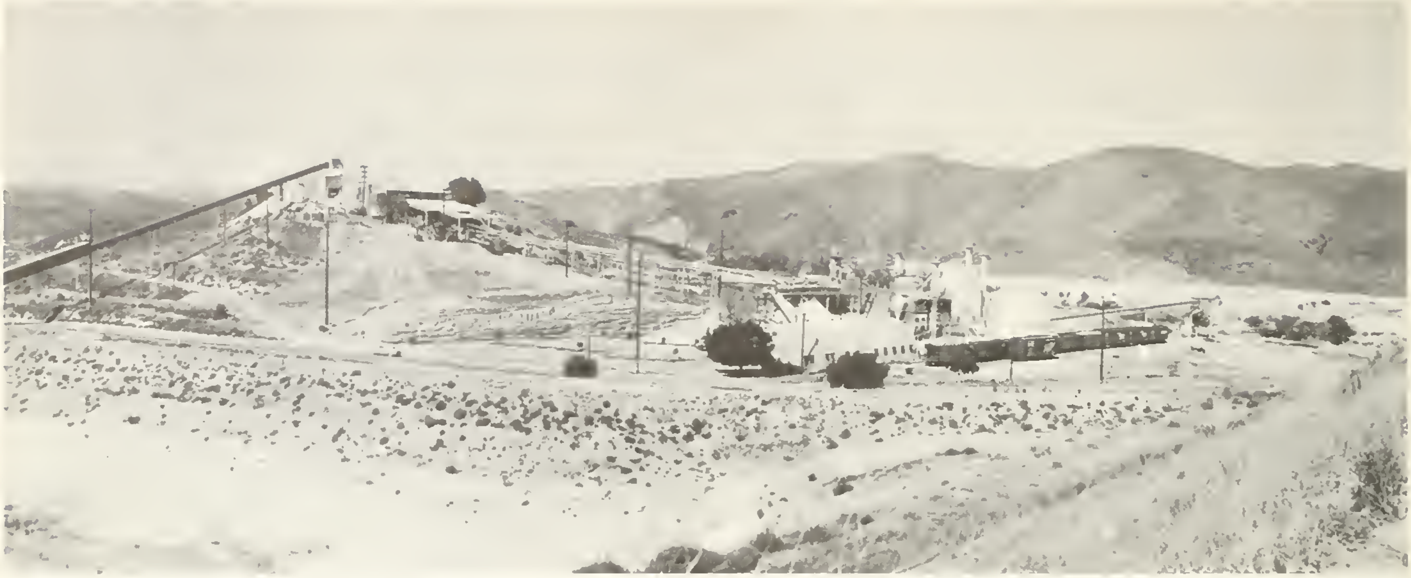

FIGURE 37. Glass sand processing plant of Owens-Illinois Glass Company at Corona. Raw material is obtained from gently dipping sandstone of the Paleocene Silverado formation (exposed in pit, center). Sand from surge pile is moved by conveyor belt (left) across State Highway 71 to the plant (left center) where it is processed for use as glass sand. Processed sand is conveyed to storage bins (right center) from which the sand is loaded into railroad cars or trucks for transport to glass manufacturing plants. Offices and laboratories are housed in quonset type building (center). Observer faces northeast. *Photograph by Thomas E. Gay, Jr.*

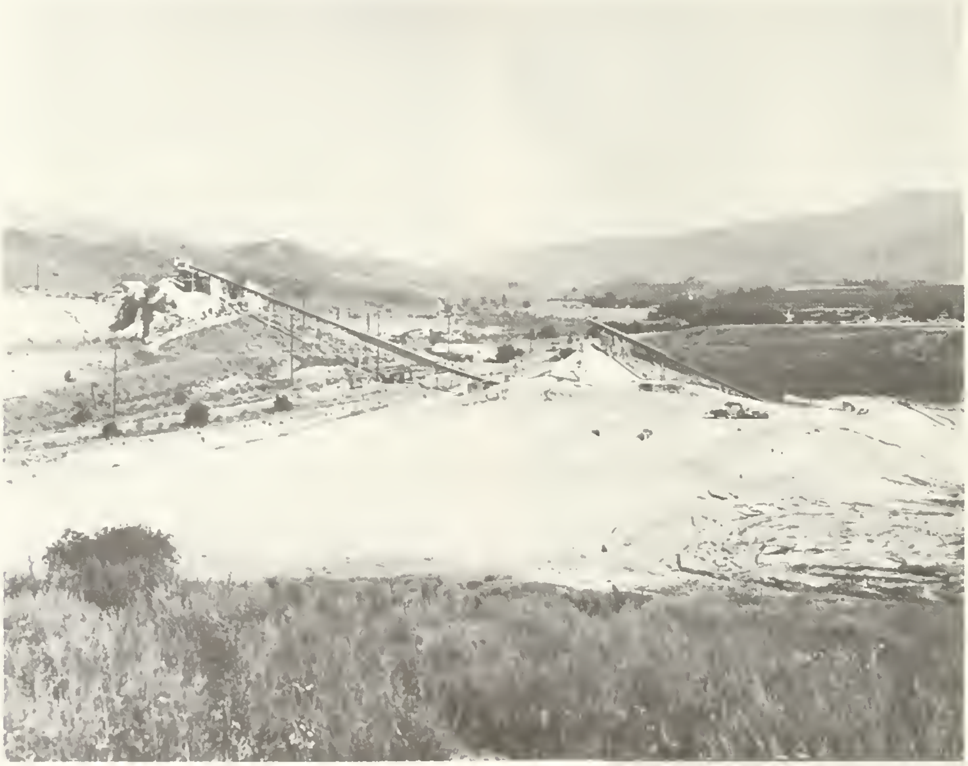

FIGURE 38. Gently dipping sandstone (Paleocene Silverado formation) exposed in pits at the Corona silica sand mine of Owens-Illinois Glass Company. Carryall scrapers transport raw sand to crusher at base of inclined conveyor (right middle distance) which supplies raw surge pile (center middle distance). A second inclined conveyor (left middle distance) conveys the sand across State Highway 71 to processing plant. Inactive pit east of highway is at left of plant, active pit (1958), which has been greatly enlarged since this photo was taken in 1956, occupies the foreground and behind conveyor at right is the largest pit, inactive since 1957. Observer faces southeast, view along the Corona-Elsinore trough. Santa Ana Mountains at right, Gavilan Hills at left. *Photograph by Thomas E. Gay, Jr.*

feet long and 600 feet wide and about 120 feet deep. Sand was blasted from the face and moved by dragline to the plant where it was screened, classified, washed, crushed, dried and passed over a magnetic separator. About 3,000 tons of material per month were produced and shipped via rail to various users for sandblasting, glass sand, and stucco plaster (Tucker and Sampson, 1945, pp. 163-164). Daily output was from 100 to 150 tons of sand which averaged about 93 percent SiO_2, 4+ percent Al_2O_3 and 3 percent alkalies with Fe_2O_3 content about 0.10 percent (Valentine, 1947, p. 1).

In the late 1940's the quarry east of the highway was abandoned and open pit operations were started in sec. 21, just west of the highway and across the road from the plant. In 1956 this quarry was crudely triangular in plan, and had dimensions of about 800 feet by 450 feet by 700 feet and a maximum depth of about 120 feet. During 1956, overburden was stripped from a large area adjoining the north edge of the pit and in early 1957 all mining was in this north extension of the pit (fig. 39).

In 1947, the Owens-Illinois Glass Company erected a modern sand treatment plant (fig. 37), which was placed in operation in January 1948. The function of the plant is to remove clay and iron-bearing constituents from the sand and to produce high grade silica sand suitable for use in the manufacture of glass.

In the pit, both stripping of overburden and mining are done with rippers and bulldozers (fig. 38). Carryalls, drawn by Caterpillar tractors, scrape up the loosened raw materials. They haul overburden to waste dumps and crude sand to a dumping hopper over the crusher pit. The crusher disintegrates the material, but does not crush the pebbles. From the crusher a belt conveyor takes the material to a raw storage pile.

From raw storage piles, the material is moved up a long belt conveyor which crosses the highway to surge bins at the mill. From there the feed is divided and directed into twin circuits in the mill where it is scrubbed, ground, and classified by size. After classification loose fines are piped as a slurry to thickeners from which the underflow (reject material) is transferred to waste ponds. About 20 to 25 percent of the raw ore is rejected at this first classification. Classified material is then scrubbed by attrition scrubbers to remove coatings of clay and iron oxide from the quartz grains which are then washed and screened into plus and minus 30-mesh fractions. Minus 30-mesh material is classified to remove fines which go to a thickener. The overflow from the thickener and the rake product from the classifier are transferred to the "amber" sand drain bins. Plus 30-mesh material from the screens is ground and classified to remove fines which go to a thickener. The rake and thickener products are screened into plus and minus 40-mesh fractions. Plus 40-mesh material is reground and classified in closed circuit; minus 40-mesh is dewatered in a Dorr classifier from which the sand goes to "flint" sand drain bins and water is reclaimed for reuse in the mill.

The clay and other fines are removed and sand of the required size and purity is prepared by the above outlined process of grinding and classifying which rejects about 45 percent of the pit run material. The sand is drained for several hours after which the relatively dry top part is pulled from the bins onto a conveyor by a reclaiming digging ladder and the material goes to driers. After drying the sand then passes over Dings magnetic Hi-intensity separators that remove magnetic impurities such as mica (biotite and muscovite), magnetite, ilmenite, epidote, zircon, tourmaline, and hornblende. Magnetic products, which comprise about 3 to 4 percent of the dry processed sand, go to waste piles and the finished sand to storage bins. Hopper bottom railroad cars and trucks are loaded directly from the storage bins and transport the sand to market.

Two grades of sand are produced: "flint" sand which is used to make colorless glass, and "amber" sand which is used in the manufacture of amber- and green-colored glass containers. The composition of the flint sand is as follows:

SiO_2	94.5% to 96.0%
Al_2O_3	2.5% to 3.5%
K_2O, Na_2O, etc.	1.8% to 2.3%
Fe_2O_3	.03% to .035%

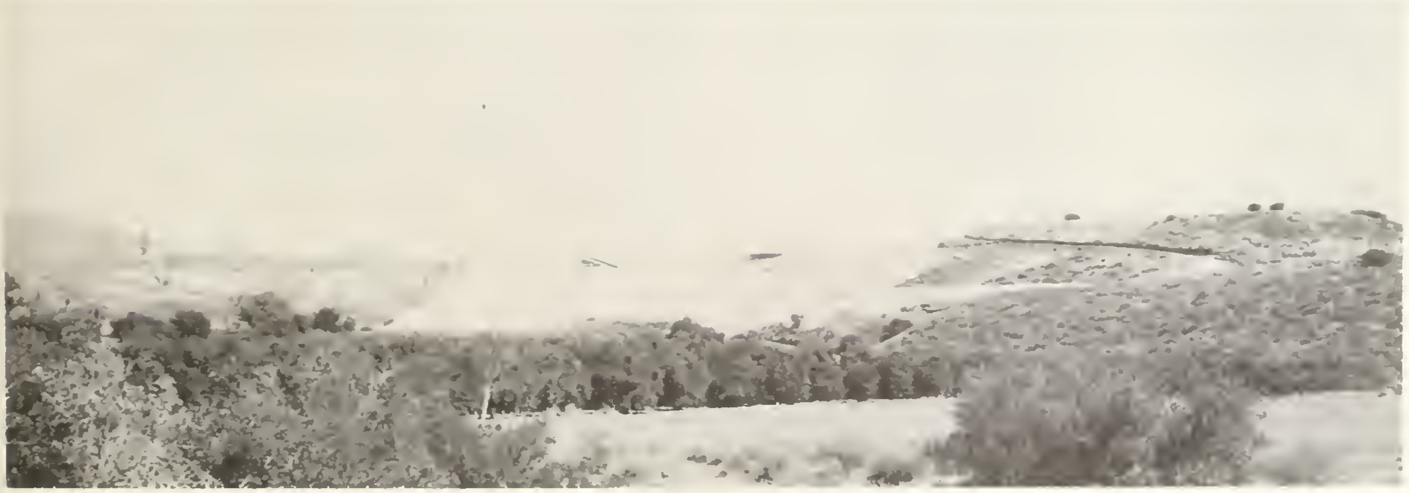

FIGURE 39. Owens-Illinois Glass Company's glass sand operation in the Corona-Elsinore trough, southeast of Corona. Inactive original pit east of highway is at left, present (1958) active pit at center and top of plant barely visible beyond. Pits are opened in Paleocene Silverado formation sandstone which is overlain by a thin covering of terrace deposits on the flat-topped ridges at both left and right. Observer faces southeast.

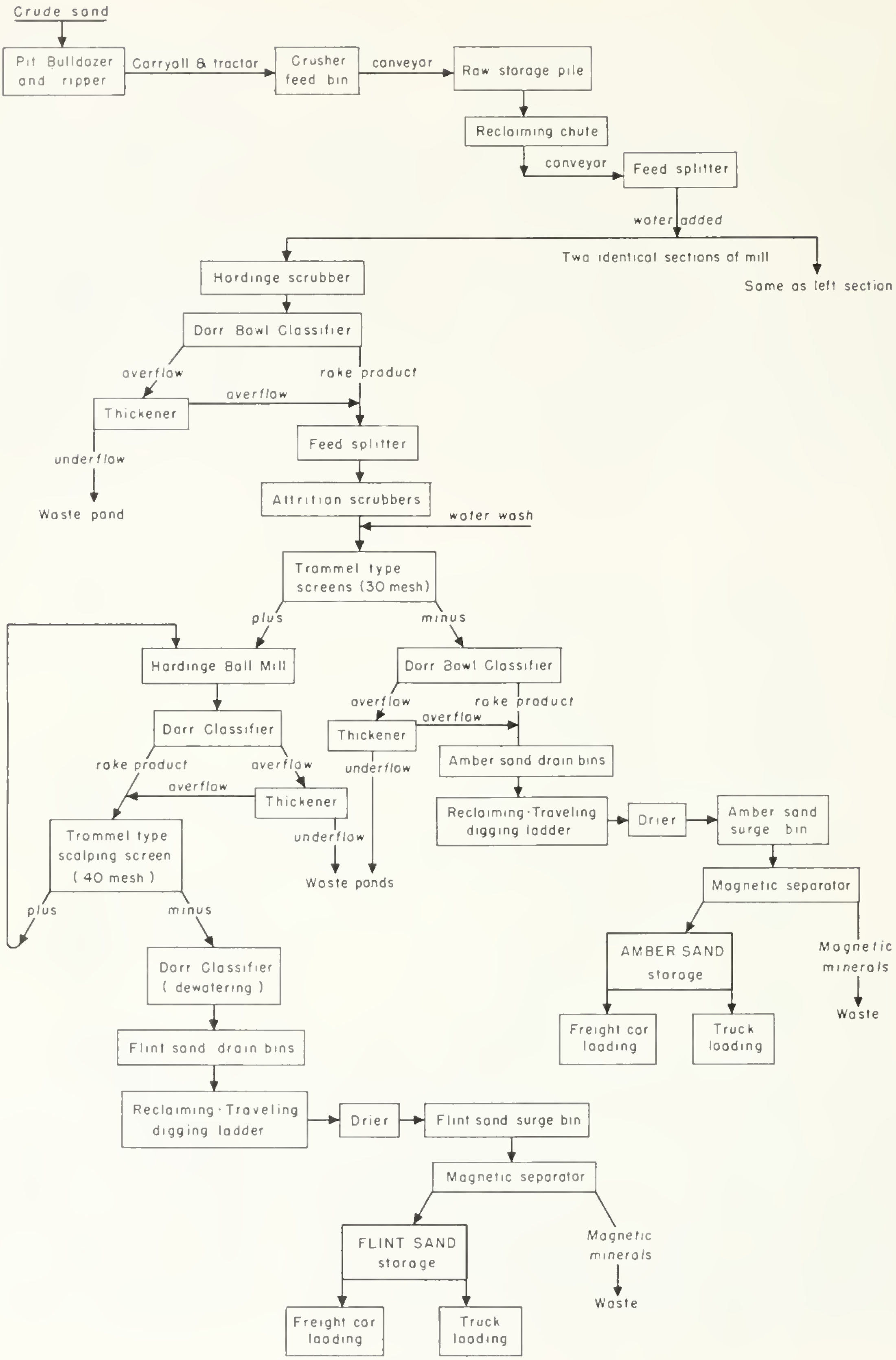

Figure 40. Generalized flow sheet of Owens-Illinois Glass Company sand treatment plant, Corona, Riverside County.

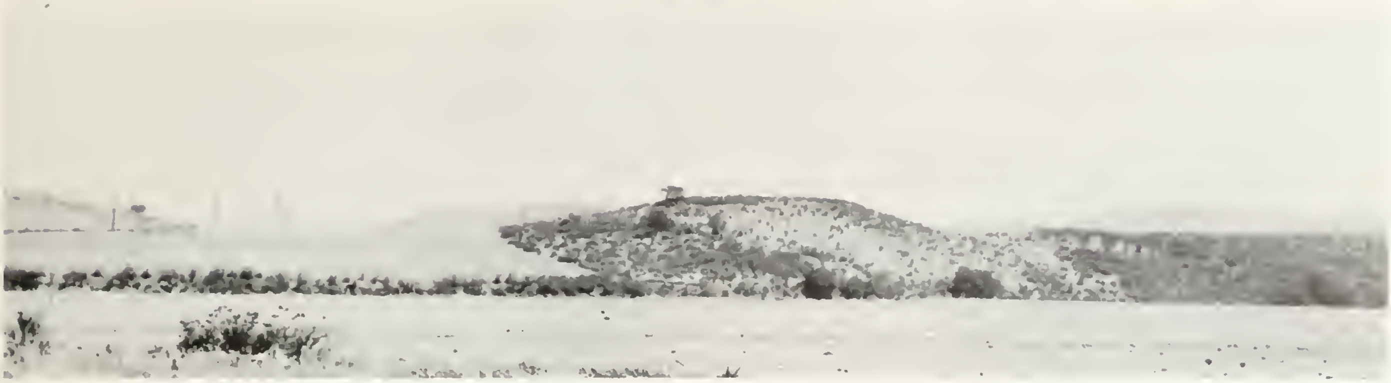

FIGURE 41. Coronita Ranch sand deposit. Flat-topped hills covered with terrace gravels are underlain by sandstone of the Paleocene Silverado formation. Corona silica sand mine is beyond low hill at left. Low areas in left and right middle distance are covered with older alluvium. Lower Bedford Wash (foreground) is covered with alluvium. Observer faces southeast.

The composition of amber sand differs from that of flint sand only in that the iron content is higher and totals from 0.04 to 0.06 percent.

Initial capacity of the plant in 1948 was 90 tons per hour of crude sand with output of about 30 tons of finished flint sand and 15 tons of amber sand per hour. Since 1950, more than 100,000 tons of finished sand have been shipped each year to the Los Angeles area.

The waste pond material contains a large proportion of clay of which a portion is used, after settling, as a constituent in the manufacture of common clay products. Since 1956 the Jordan Tile Company of Corona has used some of this material in the manufacture of red-burning quarry tile, and Hancock Brick Company, Highgrove, also uses small amounts. Since about 1948, the Liston Brick Company located half a mile north of the Owens-Illinois operation, has used small amounts of the stripped waste clay materials in the manufacture of common clay products.

The deposit appears to contain easily accessible reserves sufficient for many years of operation at current consumption rates. Vast additional reserves, although unproven, are indicated by geologic evidence to exist northwest, west and south of the present pit. However, overburden in this area may prove too thick for economic mining operations.

Coronita Ranch Sand Deposit. Location: SW¼ sec. 16, E½SE¼ sec. 17, T. 4 S., R. 6 W., S.B.M. along the east margin of lower Bedford Wash a quarter of a mile west of State Highway 71 and 6½ road miles southeast of Corona. Ownership: Joel D. Middleton, 9531 Heather Road, Beverly Hills, California, and Donald C. McMillan, 8704 Colima Road, Whittier, California, own 240 acres of patented ranch land.

The Coronita Ranch sand deposit (fig. 41) adjoins the west edge of the Corona silica sand deposit (described elsewhere in this report) and apparently is the northwest extension of the same sequence of Silverado formation sandstones and clayey sandstones which have furnished a steady supply of specialty sand for many years. On this property the Silverado sandstone crops out in one small exposure on the east bluff of Bedford Wash. Here it strikes N. 45° W. and dips 8° to 10° SW. The accompanying geologic map (pl. 1) shows the remainder of the property is covered mostly by older alluvium (Qalo) and alluvium (Qal) but one small hill is capped by terrace deposits (Qt). Low hills, which rise along the south margin of the property east of Bedford Wash, are underlain by the Sespe and Vaqueros formations, undifferentiated (Tvs).

This property was first explored for glass sand in April 1957, when 10 drill holes (fig. 42) were put down in the SW¼ sec. 16 along the southeast margin of and east of Bedford Wash. The investigation was carried out under the direction of Mr. Meredith C. Brown who kindly furnished the drill logs (fig. 43) and results of laboratory work (fig. 44). Samples were tested in the laboratories of Pacific Clay Products by Mr. Jack Kilgore, chemist. Early in 1958 the property was taken under option by the Del Monte Properties Company, P. O. Box 150, Pacific Grove, California. This company did additional drilling and sampling in this area and also on other parts of the Coronita Ranch in secs. 17, 18, 19, and 20, T. 4 S., R. 6 W., S.B.M.

The alluvial overburden ranges from 2 feet along the east edge of Bedford Wash to more than 90 feet in the east part of the property along the old county road. Five drill holes, ranging from 26 to 90 feet in depth, encountered overburden only which is shown as older alluvium on the geologic map (pl. 1). This area of thick overburden trends north-northeast and separates the two areas of thinner overburden, one on the Coronita Ranch property and the other on the adjoining Corona property. Apparently much or all of the Silverado sandstone

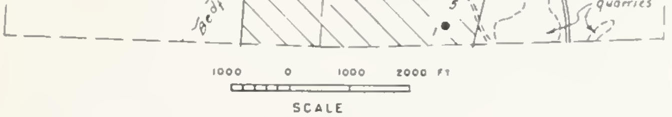

FIGURE 42. Sketch map showing location of drill holes on Coronita Ranch sand deposit.

Drill hole no. (fig. 42)	Spl. interval depth (feet)	Sample description
1	0–33.2	Rock & gravel. Rock to 6″ dia.
	33.2–38.0	Sd & gravel with sticky cl bond.
	38.0–70.0	Fine sd, cl & silt with occasional rocks. Interpretation: 0-70, older alluvium.
2	0–28.0	Overburden. Rock & gravel.
	28.0–32.0	Cs ss. Light yellow cl bond.
	32.0–38.8	Med gr ss turning from cream to white.
	38.8–40.8	Cs gr ss white.
	40.8–49.2	Fine gr ss much mica present.
	49.2–53.0	Coarser gr ss with greenish cl streaks.
	53.0–55.8	Fine grading to cs ss.
	55.8–62.0	Cs gr white ss.
	62.0–66.2	Fine gr ss much black mica.
	66.2–75.0	Cs ss much quartz. Less mica.
	75.0–81.0	Med gr ss much mica.
	81.0–88.0	Cs white ss very clean.
	88.0–90.0	As above. Slight increase in mica.
		Interpretation: 0-28, older alluvium; 28-90, Silverado fm.
3	0–26.0	Overburden. Rock & gravel. Abandoned. Rocks too large. Interpretation: 0-26, older alluvium.
4	0–69.0	Overburden. Sd, gravel, silt, & cl. Abandoned. Interpretation: 0-69, older alluvium.
5	0–43.0	Overburden. Heavy rock & gravel. Abandoned. Interpretation: 0-43, older alluvium.
6	0–24.5	Overburden. Rock & gravel.
	24.5–38.0	Fine gr ss, yellow to green. Some mica.
	38.0–42.5	Micaceous ab.
	42.5–47.3	Med gr ss, atreaks of hard gray cl.
	47.3–57.0	Fine gr ss. Mica decreasing.
	57.0–68.0	Cs gr ss, pink & white.
	68.0–82.0	Fine gr ss, gray & green. Much mica.
	82.0–90.0	Cs gr ss, tan & white. Less mica.
		Interpretation: 0-24.5, older alluvium; 24.5-90, Silverado fm.
7	0–42.0	Overburden. Rock & gravel.
	42.0–44.0	Ca ss, tan iron stained.
	44.0–69.0	Cs white ss.
	69.0–72.0	Fine yellow sd. Much mica.
	72.0–76.0	Ca white ss.
	76.0–78.0	Cs white ss with streaks of hard gray cl.
	78.0–90.0	Cs white ss.
		Interpretation: 0-42, older alluvium; 42-90, Silverado fm.
8	0–90.0	Overburden. Abandoned because of overburden depth.
		Interpretation: 0-90, older alluvium.
9	0– 2.0	Overburden, sd & gravel.
	2.0–28.0	Cs cream & white ss.
	28.0–34.5	Cs gray ss. Alternate beds of mica in streaks.
	34.5–41.8	Cs white ss some mica in streaks.
	41.8–47.0	Cs white ss little mica.
	47.0–52.5	Med gr ss much mica.
	52.5–55.0	Heavy black mica. Looks like lignite.
	55.0–90.0	Cs white & gray ss very little mica.
		Interpretation: 0-2, alluvium; 2-90, Silverado fm.
10	0– 8.0	Overburden. Sd & rock.
	8.0–15.0	Med gr cream colored ss.
	15.0–80.0	Alternate cs & med gr ss.
		Interpretation: 0-8, alluvium; 8-80, Silverado fm.

FIGURE 43. Logs of drill holes, Coronita Ranch sand deposit. *Courtesy Meridith C. Brown; interpretation added by C. H. Gray.*

Drill hole no. (fig. 42)	Spl interval depth (feet)	Total recovery (%)	+4 mesh (%)	−4+30 mesh (%)	−30+150 mesh (%)	Natural −4+30 mesh		Natural −30+150 mesh	
						Fe_2O_3 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	Al_2O_3 (%)
2	32.0-40.8	75.6	3.4	52.7	43.9	.031	5.72	.090	4.76
	40.8-49.2	68.5	1.9	27.6	70.5	.031	5.32	.142	8.01
	49.2-90.0	78.4	3.0	51.3	45.7	.024	4.83	.115	5.28
6	45.0-57.0	75.4	1.7	33.4	64.9	.044	5.41	.058	5.84
	57.0-68.0	79.5	4.3	52.9	42.8	.025	4.97	.730	8.97
	68.0-82.0	67.4	0.6	18.7	80.7	.043	7.33	.074	8.86
	82.0-90.0	77.1	1.8	48.8	49.4	.035	4.81	.119	5.93
7	44.0-90.0	79.0	3.7	53.9	42.4	.029	5.32	.032	4.92
9	2.0-52.5	80.9	3.6	57.1	39.3	.025	5.37	.030	4.47
	52.5-90.0	81.9	3.8	58.7	37.5	.026	4.77	.039	3.86
10	8.0-80.0	76.2	2.1	45.3	52.6	.029	4.17	.036	4.91
Average		76.4	2.7	45.5	51.8	.031	5.27	.133	5.98
Outcrop, east edge Bedford Wash		72.7	0.7	41.8	57.5	.039	5.86	.086	12.16

Preparation and analysis of samples: samples were split and blended; +4 mesh was removed, −4 mesh was scrubbed clean in a Fagergren laboratory cell and the clay removed by decantation. This was dried and weighted (indicated in Total Recovery column). Sample was then screened into two fractions (−4 +30 mesh, −30 +150 mesh columns). The −4 +30 mesh was ground to −30 +150 mesh. Mica was removed from this sample and the natural −30 +150 mesh material by electrostatic separation, followed by magnetic separation for removal of the iron-bearing minerals. Standard methods of analysis used by the glass industry were employed. (Data courtesy of Meredith C. Brown).

FIGURE 44. Analyses of drill hole samples, Coronita Ranch sand deposit. *Analyses by Jack Kilgore, Pacific Clay Products, May 1957.*

was removed by erosion from a rather narrow watercourse, which was later filled with alluvial debris. Medium- to coarse-grained Silverado sandstone, siltstone, and sandy clay with abundant greenish-gray mica was encountered in 5 drill holes, all of which bottomed in this formation at 90 feet. Overburden ranged from 2 to 24 feet.

Beneficiation tests and analyses of samples indicate that the Coronita Ranch sand deposit is probably of glass grade (Brown, 1957). The iron oxide content of beneficiated material is low, the deposit is favorably located in regard to transportation and is adjacent to an operating glass sand plant. The sand was not bottomed in any of the drill holes which penetrated sand indicating that substantial reserves are probably present. However, additional drilling and sampling would be necessary to give a meaningful estimate of the potential of this deposit.

Jones (Hoag Ranch) Sand Deposit. Location: SW¼ sec. 17, T. 4 S., R. 6 W., S.B.M. between Bedford and Joseph Canyons about 4 miles southeast of Corona. Ownership: Riverside Cement Company Division of the American Cement Corporation, Post Office Box 832, Riverside, California, owns 80 acres of patented ranch land.

The Jones deposit, on the old Hoag Ranch, was owned in 1925 by A. E. Jones of Corona who did some open cut development work and erected a wooden loading bin. Apparently there has been little or no production of glass sand from this property, but small amounts of sand may have been produced and used as foundry sand in the 1920's.

The deposit is composed of generally massive, poorly consolidated, white sandstone which is locally conglomeratic. It is probably of Pliocene age. Indistinct bedding appears to strike northwestward and dip about 20° southeast. The sandstone consists mostly of quartz and feldspar. In places the unconsolidated sand contains very little mica and has no visible impurities, elsewhere it contains much mica, occasional clay shale clasts and cobbles of granitic, volcanic, and metasedimentary rock. The mixed sandstone and conglomeratic sandstone is exposed over an area about 1,000 feet square. An overburden, 5 to 10 feet thick, of older alluvium covers the central and southern part. Tucker and Sampson (1929, p. 505) state that the raw material was reported to contain 97.45 percent silica and was upgraded to 97.54 percent silica after washing and screening and that the iron content ranged from 0.09 percent to 0.11 percent. As glass manufacturers usually require sands with the iron content less than 0.04 and rarely permit over 0.06 percent, the Jones sand probably would require beneficiation to reduce the iron content. A more detailed study of the quartz-feldspar ratio and much more sampling together with chemical analyses would be required to evaluate this deposit as a potential source of glass sand.

The property had been idle for many years, and only the remains of a small wooden loading bin and an open cut marked the location in 1956. In September 1958 the Riverside Cement Company, Division of the American Cement Corporation, P. O. Box 832, Riverside, California, held the property under option and did extensive drilling and sampling. At the time of writing (October 1958) the drilling had not been completed but preliminary information indicated substantial reserves of white sand, probably suitable for use in the manufacture of white portland cement. In December 1958 Riverside Cement Company announced their intention of constructing a white cement manufacturing plant adjacent to the existing Crestmore plant in West Riverside.

Temescal Canyon Silica Sand Deposit. Location: NE¼ sec. 29, T. 4 S., R. 6 W., S.B.M., 5 miles southeast of Corona southeast of Bedford Motorway and north of McBribe Canyon. Ownership: Arthur E. Garratt, 3340 Eastern Avenue, Los Angeles 32, California, owns sec. 29, formerly railroad land.

Coarse, weakly indurated, white arkose of probable upper Eocene to lower Miocene age (undifferentiated Vaqueros and Sespe formations on accompanying map) crops out over much of the N½NE¼ sec. 29, but the flat-topped ridges in this area are capped by Quaternary terrace gravels. South of these exposures is a fault sliver of Paleocene Silverado formation, composed of sandstone, clayey sandstone and clay, which crops out along the northeast side of the Elsinore fault and extends from McBribe Canyon northwest along the margin of the Santa Ana Mountains. The fault sliver is about 600 feet wide and 2,000 feet long. The Vaqueros and Sespe sandstones in the Temescal Canyon deposit area were prospected years ago by means of several shallow pits from which a small production may have been obtained. Sampson and Tucker (1931, p. 444) give the following analysis for material which presumably came from the prospect pit designated as No. 58 on plate 1:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Ign. Loss	Moisture
73.74%	12.77%	1.03%	5.25%	3.04%	0.87%	1.22%

Early in 1956 the Ottawa Silica Company, Box 437, Ottawa, Illinois, took the property under option and explored in this area and also in the W½ sec. 28 where sandstone, silt and sandy clay of the undifferentiated Vaqueros and Sespe formations crop out along McBribe Canyon. Eight 18-inch diameter drill holes, made with a cesspool digger, were put down in the Silverado formation in the NE¼ sec. 29 while the remainder of the area was explored by numerous bulldozer cuts and trenches. Samples, taken at 2-foot intervals from the drill holes and selectively from the open cuts, were tested in the company's laboratory. None of the testing data is available, but the Silverado sandstone in sec. 29 is reported to be suitable for use as glass sand, whereas the Vaqueros and Sespe sandstone in sec. 28 is not (personal communication, R. G. Crosley).

WATER RESOURCES (GROUND WATER)

Water is perhaps the most sought-after and important natural resource in the Corona area. The town of Corona and surrounding citrus groves lie in the Temescal ground water basin which has been described in some detail by Eckis (1934, pp. 178-181, plates C & D) from whom the following has been largely abstracted. This basin has a surface area of approximately 16,200 acres and is bounded by the Santa Ana River on the north; the Chino and Elsinore fault zones on the southwest; El Cerrito Hills on the southeast; and the granitic hills of the Perris Block form an irregular northeast margin. Other small alluvial basins lie to the southeast along the Corona-Elsinore trough.

No. on plate 1	Operator	Well	Location S.B.B.&M.			Date begun	Total depth (feet)	Geology and remarks
			T.	R.	Sec.			
1	Owens-Illinois Glass Company	(water well)	4S	6W	16	1947	100	100′ of Silverado fm. ss and clay. Bottomed in feldspathic biotite diorite at 100′.
2	Owens-Illinois Glass Company	(water well)	4S	6W	21	1947	325	325′ of Silverado fm. ss and clay, clay zone beneath ss; bottomed in biotite qtz. monzonite at 325′.
3	Orangethorpe Oil Co.	Orangethorpe 1	4S	6W	28	1-49	625	Spud in Qal. Reported to have encountered oil at depth of 625′ in poorly consolidated, coarse, ss and cbl cg. Pumped 2½ B/D 14.5 gr. oil.
	redrilled by: Johnson, C. H. (Fife Bros.)	redrilled as: Heinlein	------	------	------	5-50	678	Deepened to 678′; 5 B/D 90.0 cut. Pumped off 5/13/50. Abandoned 1951.
4	Frontier Petroleum Company	Barger 1	4S	6W	28	1-50	1,060	Spud in Qal; drillers log indicates probably in Vaqueros and Sespe fms., undifferentiated, ss and cg to 840′; 14′ red clay; 207′ of white, coarse, silica sd (prob. Silverado fm). Bottomed in white silica sd at 1,060′. Abandoned 2/4/50.
5	Frontier Petroleum Company or Max N. Hammerling (?)	(Undetermined)	4S	6W	21	1950	720(?)	Spud in Vaqueros and Sespe fms., undifferentiated; reported by local residents to have penetrated "granite" at 680′ and bottomed in "granite" at 720′.
6	Max N. Hammerling	M.N.H. 1	4S	6W	21	11-51	830	Spud in Vaqueros and Sespe fms. undifferentiated; drilling in sd and sh at 396′; non-commercial gas and oil shows reported; top of "granite" 763′; deepened to 830′ and converted to water well 3/3/52.
7	V.O.D. Oil Co., Inc. (Brownson Drlg. Co.)	Berghofer 1	4S	6W	29	11-50	1,823	Spud in Qt; cbl cg or breccia w/gray sandy matrix at 1,020′; gray sd at 1,064′; reported to have bottomed in sedimentary rocks at 1,640′. Converted to water well 9/15/51. Deepened to 1,823′, 1953. Abandoned 1953.
8	Kenneth E. Reed	Kincheloe 1	4S	6W	17	1-50	609	Spud in Qalo; cored, no showings; suspended 3/3/50. Converted to water well.
9	Mankin, Johnson and Johnson (Frontier Petroleum Co.)	Case 1	4S	6W	34	2-50	2,000±(?)	Spud in Qalo; total depth reported as 865′ 2/25/50, may have reached approx. 2,000′; show of oil and gas reported. Abandoned 2/17/50.
10	Elkhorn Petroleum Co.	Heinlein 1	4S	6W	28	4-49	994	Spud in Qal. Abandoned 5/2/49.
11	Palm, Peter	Peter Palm 1	4S	6W	28	6-50	825	Spud in Qal. Reported to have bottomed in ss and sh. Abandoned 1950.
12	H. & W. Associates	Marie Boyd 1	4S	6W	28	12-53	905	Spud. in Qt; oil showing reported at 310′, gas showings from 535′-545′; sd and sh at 885′; sidewall samples taken; hole caved, idle, 4/10/54; suspended 5/18/54.
13	Notterman, Nick L.	Notterman 1	4S	6W	28	5-56	851	Spud in Vaqueros and Sespe formations, undifferentiated. Apparently bottomed in greenish gray clayey sand or silt. Idle 7/21/56.
14	Croft, G. S. G.; Ingram, Alice Terry; Reiter, Ellis D; (Ciroco Oil Co.)	Ciroco-Wright 1	4S	7W	33	11-51	1,525	Spud in Qt; entered reddish sd and cg at shallow depth. Abandoned 12/5/51.
	redrilled by: Fairmont Oil Co.	redrilled as: Wright 1	------	------	------	8-54	1,597	Fairmont began deepening from 1,516′, 8/28/54; taken over by Pethyridge and Erlich at 1,597′.
	Pethyridge, Frank; Erlich, Lon W.	------	------	------	------	9-54	4,027	Ditch Spl. 2,465′, Mohnian forams; Core 2,587′-2,591′, pbl to cbl cg; core 2,900′±, oil sd, had fair odor and cut; core 2,936′-2,947′, pebbly, poorly sorted white sd, with greenish cast, large green biotite flakes, white clayey matrix, some brown colored sd, gives dark brown cut; core 2,954′-2,960′ cs gr pbl cg, white clayey matrix, no oil staining; core 3,370′-3,375′, dark gray micaceous siltstone w/streaks lt. col. sd, sparse megafauna, forams recovered reported to be Eocene (Laiming B zone). Interpretation: 0-2100′, Pliocene and Puente fm., undifferentiated; 2,100′-2,550′, Puente fm. silt; 2,550′-3,200′, Vaqueros and Sespe fms., undifferentiated; 3,200′-4,027′, Eocene, Laiming B zone; Bottomed in Eocene. Abandoned.
15	(Undetermined)	(Undetermined)	4S	6W	8	1930 (?)	1,550 (?)	Well approx. located. Spud in Topanga fm., reported black, sh at 980′; may have bottomed in hard ss at 1,550′ and be entirely in Miocene rocks. However, last 580′ drilled could be basement; black sh at 980′ might be base of Silverado fm.; Prob. drilled about 1930.

No. on plate 1	Operator	Well	Location S.B.B.&M.			Date begun	Total depth (feet)	Geology and remarks
			T.	R.	Sec.			
	Trabuca Oil Co.	Trabuca Oil Co. 1	4S	6W	28	5-25	4,500 (?)	Exact location not available. Local residents report at least one of these wells was in Brown Canyon near Orangethorpe 1 (No. 3 on plate 1), abondoned 1931. In relation to records for other wells in this area these depths are greatly in excess of the known thickness of Tertiary sedimentary rocks.
	Trabuca Oil Co.	Trabuca Oil Co. 1-A	4S	6W	28(?)	1925 (?)	4,490 (?)	
16	Charles Cather and Kenneth Sperry	Union-Wright No. 1	4S	7W	33	12 24 59	3,505	Well record: Spud in Silverado fm.; 0-1,800' Eocene & or older; 1,800' top Cretaceous; 2,450' top fault zone; 2,550' top lower Mohnian; 2,630' top middle Miocene; 3,050' top middle Eocene; 3,325' top lower Eocene; lower Eocene or Paleocene at T.D. Directional hole, bottom hole location north 212', east 15'. At bottom ran: E-log, continuous dipmeter, sidewall gun. Dipmeter at 2,750' S89W, 17°. Interpretation: 0-1,800', Silverado fm.; 1,800'-2,450', Ladd fm. undifferentiated; 2,450'-2,630', Puente fm. undifferentiated & or Pliocene, undifferentiated; 2,630'-3,050', Vaqueros and Sespe fms., undifferentiated (?); 3,050'-3,505', Eocene (Santiago fm.?), lower part (3,325'-3,505') may be Silverado fm. Abandoned 1 14 60.
	CA-SP No. 2		From SE Cor. Sec. 33, 2,100'N, 900'W. Elev. 791'KB					

Figure 45. Summary of records of wells drilled in Corona South quadrangle, compiled from Division of Mines Special Report 45 (Jennings and Hart 1956, pp. 63-64), scout reports, unpublished driller's logs and private reports, and observation by the writer.

The Temescal basin is connected by alluvial fill with the Arlington basin to the northeast and the Chino basin to the northwest. The depth of the Temescal basin is not known accurately but the maximum depth of the water-bearing alluvial series in most places may be from 300 to 400 feet. The basin is apparently an alluvium-filled trough sloping to the northwest into the deeper part of Upper Santa Ana Valley.

Probably the major source of groundwater is percolation of run-off from Santa Ana Mountains streams and from Temescal Wash. Rainfall penetration, return irrigation water imported from upper basins, and underflow from Arlington basin all contribute to the supply.

In the foothills of the Santa Ana Mountains, southwest of the margin of the Temescal basin as delineated by the Chino and Elsinore fault zones, wells have been drilled in the upper parts of most of the major canyons. In general these wells have met with little success as the alluvial material that could contain water is very shallow and of limited areal extent. The wells that have been moderately successful have almost surely penetrated faults or fracture zones in the underlying volcanic, metamorphic, or older sedimentary rocks. Numerous natural springs are found along the trace of the Elsinore fault but commonly produce only a small trickle of water during the winter to early summer seasons. However, some have been developed to provide a small supply of water throughout the year. At several places, especially on the west edge of Bedford Canyon and between Brown and Bixby Canyons, large tunnels have been driven into fault zones in search of water. Flows of 10 to 20 gallons per minute are locally obtained where fracture zones are penetrated in tunnels. However, the stored water generally drains out in a short time and, without rainfall penetration recharge, the flows usually drop to small fractions of their initial discharges. The method of tunneling is in general too expensive and uncertain to be practical, the maximum probable obtainable water being too slight to warrant the risk.

PETROLEUM

Exploration for oil in the Corona area has been carried on in a small way for at least 40 years. Records (fig. 45) indicate 15 wildcat oil wells have been drilled within the Corona South quadrangle since 1925, and there probably are others of which there is no record. Twelve of these wells were put down in the period 1949-56. The others were drilled during an earlier exploration period (1920-30?). Several operators now (1958) hold oil and gas leases and more wells probably will be drilled. Records of lease applications on file with the U. S. Bureau of Land Management show that applications for oil and gas leases have been made several times on nearly all the public domain within the Corona South quadrangle, even in those areas underlain by Triassic metasedimentary and Jurassic (?) volcanic rocks.

To date, all efforts to develop petroleum along the northeastern margin of the Santa Ana Mountains have met with little success although large amounts of oil are produced from Miocene and Pliocene beds in the Puente Hills, only a few miles to the northwest. During the period 1949-56, the Orangethorpe Oil Company and several other operators drilled 12 wells between Bedford and Brown Canyons. The Orangethorpe No. 1 (3 on pl. 1) in Brown Canyon is reported to have encountered oil at a depth of 625 feet in a poorly consolidated coarse sandstone and cobble conglomerate (probably Silverado formation). A 14.5-gravity oil was pumped at the rate of 2½ barrels a day for about a month and the well was finally abandoned in 1951. Some of the other holes, including M. N. H. No. 1 and Marie Boyd No. 1 (6, 12 on pl. 1) may have encountered non-commercial gas and oil shows, but no other production has been reported. All of these wells apparently represent attempts to locate structural traps in Tertiary sedimentary rocks of the easternmost part of the much-faulted Arena Blanca syncline. Small fault slivers of upper Miocene Puente formation, undifferentiated sandstone and shale and Pliocene (?) sandstone and shale, as well as larger bodies of

Map no. (fig. 47)	Claim name		Location S.B.B.&M. Section	T.	R.	Patent number	Serial number	Date of patent	Survey number	Size in acres	Original patent owner	Patent owner (1957)	Status (1958)
1	Fire Clay No. 1 Placer	Fire Clay group	NE¼ 5 NW¼ 4	4S	7W	360331	012815	1913	4838	20	J. H. Moore; Geo. T. Mabey, Corona	Clifford & Maude M. Tillotson, P.O. Box 237, Corona	Idle
2	Fire Clay No. 2 Placer		SW¼ 4	4S	7W	360331	012815	1913	4838	20	do.	do.	Idle
3	M & M Placer		SE¼ 5	4S	7W	360331	012815	1913	4838	20	do.	do.	Idle
4	Susie Placer		SW¼ 4	4S	7W	365178	012814	1913	4837	20	W. G. McVicar, Daisy M. Terpening, Corona	Pac. Clay Prod., 1255 W. 4th St., Los Angeles	Active
5	Leo Lorenzo	Dutch, (Keno, Kroonen) group of placers	SW¼ 4	4S	7W	611465	024140	1917		20	Leo Kroonen, Corona	John Tillotson, 807 Park Lane, Corona	Idle
6	Victor		SW¼ 4	4S	7W	611465	024140	1917		20	do.	Mary L. Kroonen, 708 W. 8th St., Corona	Idle
7	Little Canyon		SE¼ 4	4S	7W	611465	024140	1917		20	do.	do.	Idle
8	Dutch Republic		SE¼ 4	4S	7W	611465	024140	1917		18.15	do.	do.	Idle
9	Big 4		NE¼ 9	4S	7W	611465	024140	1917		20	do.	do.	Idle
10	White Clay		NE¼ 9	4S	7W	611465	024140	1917		8.23	do.	do.	Idle
11	Kroonen		NE¼ 9	4S	7W	611465	024140	1917		18.42	do.	do.	Idle
12	Black Chief		NE¼ 9	4S	7W	611465	024140	1917		20	do.	do.	Idle
13	Keno		NW¼ 10	4S	7W	611465	024140	1917		15	do.	do.	Idle
14	Luckey	McKnight group	SW¼ 3 NW¼ 10 NE¼ 9	4S	7W	210		1905	4045	16.48	Pac. Clay Mfg. Co.	Pac. Clay Prod. 1255 W. 4th St., Los Angeles	Idle
15	Trio		NW¼ 10 NE¼ 9	4S	7W	210		1905	4045	17.34	do.	do.	Idle
16	McKnight		SW¼ 3 NW¼ 10	4S	7W	210		1905	4045	18.51	do.	do.	Idle
17	Findley Feldspar Placer		SE¼ 33	3S	7W	917651	034485	1923		20.30	M. W. Findley, G. R. Freeman, Ada Tillotson, Corona	Ray & Irma B. Overacker, 412 Olive St., Huntington Beach, Calif., less about 5 acres owned by Harold F. Stowe	Idle
18	Findley Feldspar Placer No. 2		SE¼ 33	3S	7W	917651	034485	1923		17.07	do.	do.	Idle
19	Findley Graphite Placer		NW¼ 4	4S	7W	616413	029643	1918		24.78	E. B. Collier, M. W. Findley, Corona	Otto E. Thomas, 338 S. Normandie, Los Angeles	Idle
20	Conduit Clay Placer No. 1		SE¼ 32	3S	7W	578678	027524	1917		132.11	Ira J. Coe	Riverside Cement Co., P.O. Box 832, Riverside	Idle
21	Conduit Clay Placer No. 2		SW¼ 33	3S	7W	600254	027525	1917		62.5	do.	Ray & Irma B. Overacker, 412 Olive St., Huntington Beach own N. 22 acres, Riverside Cement owns S. 40 acres	Idle
22	Corona Placer		NW¼ 14	4S	7W	441190	014126	1914	4839	18.72	H. E. Ganahl, Corona	A. E. Ganahl, 1011 Victoria, Corona	Idle

FIGURE 46. List of patented mining claims, Corona South quadrangle, California. Data are from records of the U. S. Bureau of Land Management and the Riverside County Assessor, September 1956.

Paleocene Silverado formation sandstone, shale and conglomerate and upper Eocene to lower Miocene Vaqueros and Sespe formations, undifferentiated siltstone, sandstone, and conglomerate are exposed in the area. However, the areal extent of the Miocene and Pliocene strata is very small, and, the data furnished by the wildcats suggest that the Tertiary sequence is generally thin. The evidence now available points against the discovery of a noteworthy oil field in the Brown-Bedford Canyon region. The small amounts of oil previously discovered may well have migrated along the Chino fault zone from producing Miocene or Pliocene zones in the Puente-Chino Hills, about 12 miles to the northwest.

The area south of Corona between El Cerrito Hills and Wardlow Wash has been explored only by the Ciroco-Wright No. 1 well (14 on pl. 1)*. This well, started in 1951 and abandoned in 1954, probably penetrated both Miocene and Eocene marine sedimentary rocks including some oil sands but there was no production. This well was drilled southwest of the projected trace of the Chino fault. The entire area between Corona and this well is covered by older alluvium, and the depth and character of the sedimentary sequence which lie beneath the alluvium are unknown to the writer. The hope of finding oil in the Corona area seemingly rests in the possibility that oil-bearing Tertiary rocks occur there. However, most of the Tertiary sequence may have been removed by erosion before deposition of the fanglomerates.

The records of drilling operations in the earlier period of exploration are very indefinite and generally are incompatible with data from the recent drilling. The known data for the earlier ventures, as well as the current, for wells drilled on the Corona South quadrangle are summarized in fig. 45.

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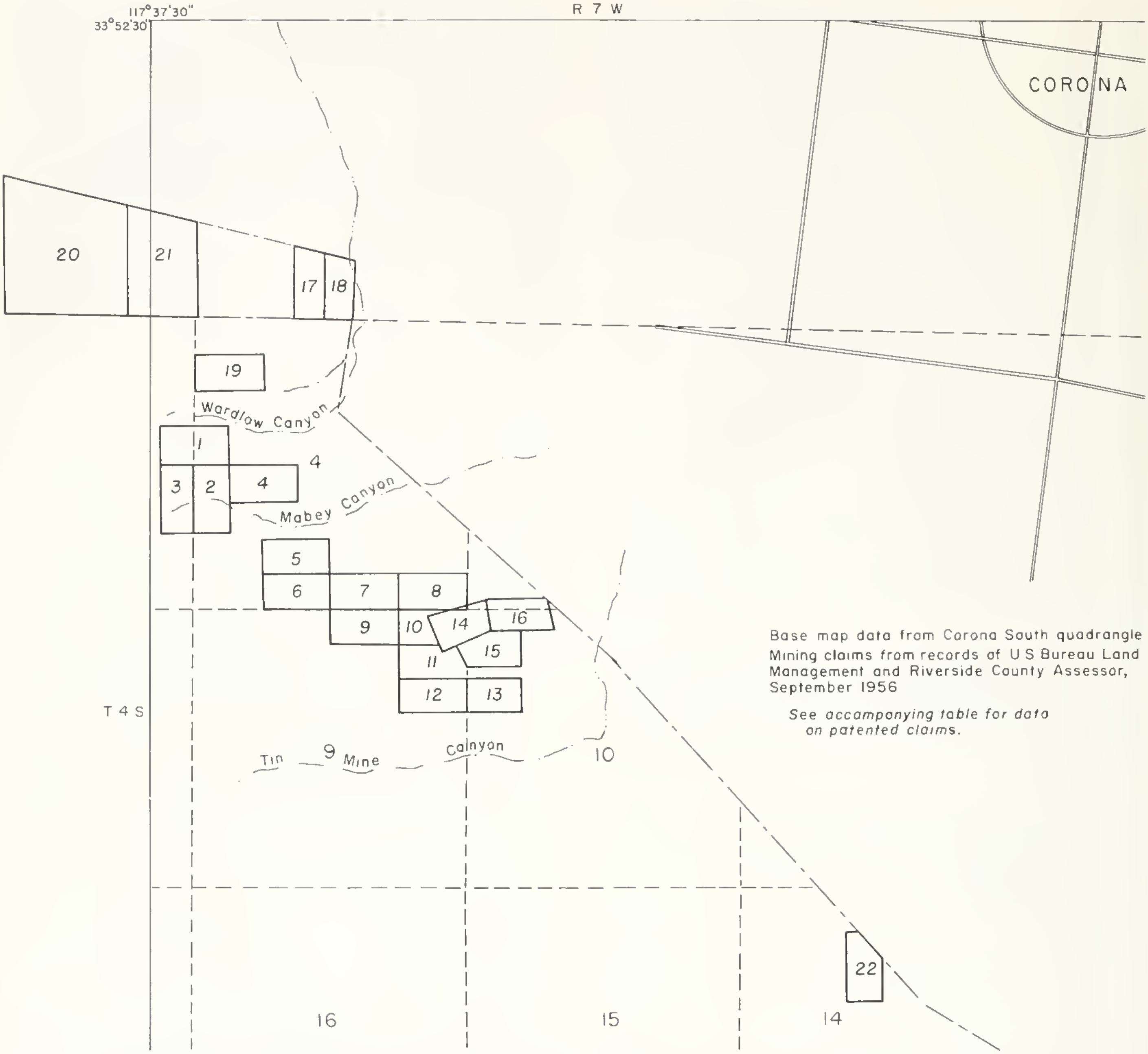
* In December 1959, after this manuscript was prepared for publication, the Union-Wright No. 1 well (no. 16 on pl. 1 and fig. 45) was drilled 700 feet southwest of Ciroco-Wright No. 1.



Base map data from Corona South quadrangle
Mining claims from records of U S Bureau Land Management and Riverside County Assessor, September 1956

See accompanying table for data on patented claims.

FIGURE 47. Index map showing patented mining claims in and adjacent to the Corona South quadrangle.

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TABULATED LIST OF MINES AND MINERAL DEPOSITS IN CORONA SOUTH QUADRANGLE

The data contained in the following tabulated list were drawn from investigations by the writer as well as from other sources, both published and unpublished, believed by the writer to be authentic. All properties listed were visited during 1956-57.

The list is arranged in alphabetical order by mineral commodity. The number in the first column is the number given the location of the deposit on the map, plate 1, in pocket. Synonyms are given in parentheses after the preferred name and appear as cross references elsewhere in the list.

The date of ownership appears in parentheses following the owner's name and address. Former owners and operators are listed below the present owner. Many of the ownership data were obtained from the offices of the Assessor and Recorder, Riverside County. Ownership data are believed to be accurate as of the time the report was written, but the data commonly were not completely verified. Uncertain section locations are followed by a question mark; the abbreviation "proj." indicates incomplete public land survey lines on the base map. Locations in miles from Corona are from 6th and Main Streets and are approximate airline distances unless otherwise indicated.

References appear in parentheses in the last column and refer to the accompanying bibliography. Only the last names of the authors are given. The first number after each name is the year of publication, and is separated from the page reference by a colon. Succeeding references are preceded by semicolons. The term "herein" refers the reader to a description in the body of the text of this report.

CLAY

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
1	Bedford Canyon deposit (Corona clay deposit)	Gladding, McBean and Co., 2901 Los Feliz Blvd., Los Angeles 39 (1957)	N½ 16	4S	6W	SB	Five miles southeast of Corona, west side of Temescal Wash in lower Bedford Canyon. Large deposit of red-burning clay of Paleocene Silverado formation, both residual and sedimentary clays. Discovered in 1954; plant construction began in 1956, placed in operation with intermittent large-scale open-pit mining in January, 1958. (Stauffer 46: map station 32; Ceramic News Aug. 56:17; Nov. 56:22; herein.)
	Brown Star claims						See Middlesworth.
2	Cajalco pit	Louis A. Weisel, et al., La Habra, own patented ranch land in this area (1957); leased by Pacific Clay Products during the 1930's	NE¼ 16	4S	6W	SB	East side of Temescal Wash about 5 miles southeast of Corona, south of Cajalco Rd. along east side of railroad. Residual red mottled clay derived from Triassic Bedford Canyon argillites and/or slates; bright brick-red clays about 30 ft. thick grade laterally into mottled grayish green clays and gray clays, thence into unaltered argillites. Overlain unconformably by coarse, weak, sandstone of Paleocene Silverado formation, 0 to 5 ft. thick which is capped by 10 to 20 ft. of angular cobble and boulder conglomerate of Quaternary age. On the south this sequence is in fault contact with Bedford Canyon quartzite and hornfels. Exploited by irregular quarry about 100 ft. long, 10 to 30 ft. high; old mine rails may mark sites of two small adits, now obliterated. Deposit apparently has very little areal extent beyond the quarry limits. Developed and operated by Pacific Clay Products for a short time in early 1930's. Production undetermined, but apparently small. Idle since 1938.
	Castillo's						See under coal.
3	Chocolate Drop	Francis A. Stearns, Box 262, Corona (1957)	NW¼ NW¼ 17	4S	6W	SB	About 3½ miles southeast of Corona at the south margin of El Cerrito Hills. Pale gray, diatomaceous, clay shale is mined from a low isolated hill (see photograph in text) composed of upper middle Miocene shale (Topanga formation). Material is scraped from hillslope and stockpiled by International TD9 combination bulldozer-loader; sparse limy concretions are removed by hand sorting; clay shale is loaded on small dump trucks and transported about 1½ miles to Liston Brick Co. for use in common red brick. Small tonnage mined each year by Liston Brick Co. since pit opened in 1948. See Liston Brick Co. under clay products manufacturing plants.
4	Conduit clay placer	Riverside Cement Co., Box 832, Riverside, owns Conduit No. 1 (132 acres) and south 40 acres of Conduit No. 2. Ray and Irma B. Overacker, 412 Olive St., Huntington Beach, own north 22 acres of Conduit No. 2 (1957)	SW¼ 33 SE¼ 32	3S	7W	SB	West edge of Corona South quadrangle, 3½ miles southwest of Corona. Two patented placer claims (Conduit Nos. 1 & 2); east part of Conduit No. 2 is on Corona South quadrangle, remainder and Conduit No. 1 are on adjoining Black Star Canyon quadrangle. Clay shales of Upper Cretaceous Ladd formation were prospected for clay about 1900 and the property was patented in 1917. Riverside Cement Co. acquired their holdings prior to 1950. Late in 1956 the property was explored by extensive bulldozer cuts, mostly on the property in Black Star Canyon quadrangle; numerous samples were taken and chemical analyses were made in an effort to find material suitable for pozzolanic additives for use with portland cement. Only sandy to very sandy clay shales were exposed. These have no apparent economic value at present. Production, if any, must have been small. Long inactive except for the exploratory work done in 1956.
	Corona clay deposit						See Bedford Canyon deposit.
5	Corona placer (Lord?)	A. E. Ganahl, 1011 Victoria. (P.O. Box 643) Corona (1957)	NW¼ 14	4S	7W	SB	West side of Main St. Canyon about 3½ miles southwest of Corona; adjoins east edge of Middlesworth clay, which see herein. Clay was mined from the Paleocene Silverado formation in the early 1900's. Long idle. (Aubury 06:223, 339; Tucker and Sampson 45:161; herein.)
	Corona shale mine, Pacific Clay Products						See Sky Ranch Clay Company deposits.
	Dutch placer						See Kroonen deposit.

CLAY—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
6	Eagle Canyon (Fraser)	T. A. and F. M. Fraser, 718 Howard St., Corona (1957); leased to Dr. Leon N. Katz, 9837 Foothill Blvd., San Fernando (1943-44)	SW¼ 13	4S	7W	SB	Four miles south of Corona; part of Eagle group of unpatented placer claims (see Eagle Canyon gypsum herein). Shallow prospect pits and small open cuts along the west side of Eagle Canyon and in Manning Canyon to the west expose sandy clays and clay shales of the Paleocene Silverado formation. Dr. Katz shipped several truck loads of "fire" clay from the west side of Eagle Canyon in 1941 to several plants in Los Angeles which tested it for flue tile, but found it to be unsuitable. Production small. Idle.
7	Emsco pit	Mrs. Graciosa and Bernard W. De Pipkins, Harvard St., Los Angeles (1956); Emsco Refractories Co., Southgate (operator; 1937-40); patented ranch land.	SE¼ 33	3S	7W	SB proj.	East bank, Wardlow Wash, 3 miles southwest of Corona. Red mottled sandy clay of Paleocene Silverado formation exposed in small quarry. Opened in 1937 by Emsco Refractories Co. when a few hundred tons of gray, sandy, carbonaceous high-refractory clay were shipped to their Southgate plant. Clay zone reported to be about 8 ft. thick, dipping 45° ± east. Mined from open quarry by power shovel, but open pit mining proved impractical because of steep dip; later an adit was driven N. 50° E. about 250 ft. south of quarry and some clay was mined; ceased operation about 1940. Clay zone not found in quarry at time of visit (1950). Adit was inaccessible, but lignite, carbonaceous clay and impure reddish-brown sandy clay were on dump. Adit and dump were destroyed by Metropolitan Water District pipe line 1956. Production undetermined, but apparently small. Idle since about 1940.
8	Findley feldspar placer	Ray and Irma B. Overacker, 412 Olive St., Huntington Beach (1957)	SE¼ 33	3S	7W	SB	Along west bank of Wardlow Wash, about 3 miles southwest of Corona. Two patented placer claims (Findley feldspar Nos. 1 & 2). Pods and irregular stringers of red, white, and gray mottled and white and purple mottled clays in matrix of weak, coarse, white arkose of Paleocene Silverado formation with some cobble conglomerate; sandstone beds strike N. 70° E., dip 30° NW. Explored by several open cuts; perhaps also by underground workings, now caved. This may be the location of one of the glass sand deposits noted by Aubury (1906, p. 375) as under development by the Corona Pressed Brick Co., about 1905. The property is said to have produced a considerable tonnage of clay about 1920 used in brick plants in Los Angeles area; no record of production found. Idle since long before 1938 when acquired by present owners.
9	Findley graphite placer mine	Otto E. Thomas, 338 So. Normandie, Los Angeles (1956), reported purchased by Omar Short, Santa Ana (1957)	NW¼ 4	4S	7W	SB	About 3½ miles southwest of Corona, north of Wardlow Canyon. One patented placer claim (Findley graphite placer). Thin discontinuous zones of impure red and green sandy clays occur in shear zones in Upper Cretaceous sandstone and conglomerate of the Ladd formation, undifferentiated. Explored about 1900 by shallow open cuts and one adit said to have showings of "graphite", not found in 1956. Clay zones have been exposed in bulldozer cuts made in late 1940's. Exposed clay not of current economic interest. Little or no production. Idle.
10	Fire clay group	Sky Ranch Clay Co., (Clifford Tillotson, owner) P.O. Box 237, Corona (1957)	4, 5	4S	7W	SB	Both sides of Mabey Canyon, 3½ miles southwest of Corona; 3 patented placer claims; Fire Clay No. 1, Fire Clay No. 2, M. & M. placer. Upper Cretaceous clay shale of the Holz shale member of the Ladd formation was explored by 4 short adits and 7 open cuts before 1910. Production from this period undetermined. Sky Ranch Clay Co. mined a small tonnage from an open cut about 1950. See Sky Ranch Clay Co. deposits herein.
	Fraser						See Eagle Canyon.
	Freeman clay	Undetermined (1957); G. R. Freeman, Corona (operator, 1927)		4S	7W	SB	G. R. Freeman, Corona, reported some clay production in 1920's. Exact location not reported, probably various deposits between Main St. and Hagador Canyons, about 3½ miles southwest of Corona. Long inactive. See Middlesworth clay and Corona clay placer, herein.
11	Grapevine	Mrs. Mary A. Mattey, 11359 Biona Ave., Los Angeles 66 (1957)	SE¼NW¼ SW¼ 4 (lot 9)	4S	7W	SB	Three miles southwest of Corona, south side of Mabey Canyon. Clay shale of the Upper Cretaceous Holz shale member of the Ladd formation; active. (Herein.)
	Hoag Ranch						See Jones.
	Hoffman						See Jones.

CLAY—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
12	Jones (Hoffman, Hoag Ranch)	Mrs. D. C. Hammond, 2955 E. California, Pasadena (1956); purchased by Coronita Ranch, c/o D. C. McMillan, 8704 Colima Rd., Whittier, in late 1957	NW¼ 19	4S	6W	SB	Clay and coal prospect 4 miles southeast of Corona (Tucker 21:325; Tucker & Sampson 29:500-501; Sampson 35:520; herein.)
	Keno group	----------	----------	------	------	------	See Kroonen deposit.
13	Kroonen deposit (Keno group, Dutch placer)	Mary L. Kroonen, 708 West 8th St., Corona (8 claims 1957) and John Tillotson, 807 Park Lane (P.O. Box 398) Corona (one claim, 1957)	S½ 4 NE¼ 9 NW¼ 10	4S	7W	SB	About 3½ miles southwest of Corona, west of and adjoins McKnight mine, between Tin Mine and Mabey Canyons; 9 patented placer claims. Sedimentary clays of the Paleocene Silverado formation. Small intermittent production during first quarter of the century. Long inactive. (Tucker & Sampson 29:501; herein.)
14	Leo Lorenzo placer	John Tillotson, 807 Park Lane, Corona (1957)	N½ SE¼ SW¼ 4	4S	7W	SB	See Kroonen deposit.
	Lord	Undetermined (1957). George W. Lord, Corona (operator, 1905)	----------	4S	7W	SB	Exact location unknown. Light gray, fine-grained fire clay reported under development in 1905. May be same as Middlesworth clay or part of Corona placer, described herein. Long inactive. (Aubury 06:223.)
15	McClintock pit	Pacific Clay Products, 1255 West Fourth St., Los Angeles (acquired Sept. 1, 1957); Sky Ranch Clay Co., P.O. Box 237, Corona (owner, 1955-1957); Earl M. McClintock, P.O. Box 34, Olive (owner, 1952)	NW¼ SE¼ 4	4S	7W	SB	Three miles southwest of Corona, on north side of Mabey Canyon. Red mottled sandy clay lenses in Paleocene Silversado formation sandstone and conglomerate; furnished a small amount of clay for use in sewer pipe to the Mission Clay Products Corp., Olive, about 1952. Developed by open cuts; exploratory bulldozer work in 1956 failed to expose economic clay. Idle.
16	McKnight clay mine	Pacific Clay Products, 1255 West Fourth St., Los Angeles (1957)	NE¼ 9 SW¼ 3 NW¼ 10	4S	7W	SB	Three miles southwest of Corona between Tin Mine and Mabey Canyons. Large amounts of red-burning clay and fire clay were produced from Paleocene Silverado formation sedimentary clays from about 1885 to the middle 1930's. Idle since then except for small intermittent production of red-burning clay. (Goodyear 88:505; Crawford 96:616; Aubury 06:224; Merrill 19:569-570; Boalich and others 20:89-90; Dietrich 28 179, 277; Tucker & Sampson 29:502; Sampson 35:520; Sutherland 35:75-79; herein.)
	McVicar pit	----------	----------	------	------	------	See Susie placer.
17	Middlesworth (Brown Star claims) (Lord?, Freeman?)	Josephine Middlesworth, 847 W. 9th St., Corona, and William H. Redding, et al., 1008 S. Pacific Ave., San Pedro (1957)	NW¼ 14 NE¼ 15 SW¼ 11	4S 4S 4S	7W 7W 7W	SB SB SB	About 3½ miles southwest of Corona between Main St. and Hagador Canyons. Paleocene red "pottery clay" and pisolitic "bauxite" were mined intermittently during first third of the century. Property examined in 1943 by Kaiser Steel Corp. as source of alumina-rich clay. Amount of production unknown. Idle. (Aubury 06:223; Draper 44:1-11; Tucker & Sampson 45:161; herein.)
18	Peterson's claim	Arthur E. Garratt, 3340 Eastern Ave., Los Angeles 32 (1957); patented land, formerly railroad section. Elsinore Clay Co., Box 421, Riverside (operator, 1930?)	N½ 29	4S	6W	SB	About 5½ miles southeast of Corons, between Bedford Motorway and McBribe Canyon. Red mottled clay and sandy gray to white clay with minor pisolitic zones intercalated in sandstone and conglomerate of the Paleocene Silverado formation; adjacent to Elsinore fault zone. Some development as early as 1892 (indicated on U. S. Bureau Land Management survey map dated 1892). Several open pits, dug about 1930, may have yielded small amounts of clay. Bulldozer cuts were made in NE¼ sec. 29 during 1956 in an unsuccessful effort to discover glass sand. Reserves of clay appear to be very small. Production undetermined, but probably small. Long idle.
	Red Bull claims	William H. and Leona Redding, A. F. and Carolyn Bullard, 1008 S. Pacific Ave., San Pedro (1957)	----------	------	------	------	See Middlesworth.
	Sky Ranch Clay Company deposits	Sky Ranch Clay Co. (Clifford Tillotson, owner) P.O. Box 237, Corona, (1957). Susie placer, McClintock pit and Sky Ranch clay mine, west pit were purchased Sept. 1, 1957 by Pacific Clay Products, 1255 West Fourth St., Los Angeles, who continued mining the Sky Ranch clay mine, west pit, as Corona shale mine	W½ 4 E½ 5	4S	7W	SB	Along Mabey and Wardlow Canyons and intervening ridges, 3½ miles southwest of Corona. Includes Susie placer (McVicar pit); McClintock pit; Fire Clay group; Sky Ranch clay mine, east and west pits; and Leo Lorenzo placer, which see herein. Intermittent production of sedimentary Paleocene Silverado formation clays since about 1900. Steady production of clay shale from Upper Cretaceous Ladd formation and Holz shale member since about 1950. Currently furnishes raw materials to Tillotson Refractories Co., Corona. (Aubury 06:223; herein.)

CLAY—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
19	Sky Ranch clay mine, east pit	Sky Ranch Clay Co. (Clifford Tillotson, owner) P.O. Box 237, Corona (1957)	NE¼SW¼ NW¼ 4	4S	7W	SB	North side of Wardlow Canyon, 3½ miles southwest of Corona; Frenchy placer claim (unpatented). Quarry opened in 1951 and until 1956, steadily furnished a considerable tonnage of clay shale from Upper Cretaceous Ladd formation to Tillotson Refractories Co., Corona. Idle since 1956. See Sky Ranch Clay Co. deposits herein.
20	Sky Ranch clay mine, west pit	Sky Ranch Clay Co. (Clifford Tillotson, owner) P.O. Box 237, Corona (1957) Patented ranchland (75 acres) in the S½NE¼ sec. 5 purchased Sept. 1, 1957 by Pacific Clay Products, 1255 West Fourth St., Los Angeles. Mining continues in this area to supply the Corona plant of Pacific Clay Products (formerly Tillotson Refractories Co.)	NW¼SW¼ NW¼ 4, S½NE¼ 5	4S	7W	SB	North side of Wardlow Canyon, 3½ miles southwest of Corona; Frenchy placer claim (unpatented, NW¼ SW¼NW¼ sec. 4); patented ranch land S½NE¼ sec. 5 (75 acres). Quarry opened early in 1956 in the S½NE¼ sec. 5, and has since furnished a considerable tonnage of Upper Cretaceous Ladd formation clay shales to the Tillotson Refractories Co., Corona. In 1957 this pit was the company's principal source of clay shale. Quarry developed in a clay shale zone which is about 500 ft. wide east-west and extends about 1,500 ft. northwesterly. See Sky Ranch Clay Co. deposits herein.
21	Susie placer (McVicar pit)	Pacific Clay Products, 1255 West Fourth St., Los Angeles (acquired Sept. 1, 1957); Sky Ranch Clay Co., (Clifford Tillotson, owner) P.O. Box 237, Corona (1954-Sept. 1, 1957)	NW¼ 4	4S	7W	SB	Ridge north of Mabey Canyon, 3½ miles southwest of Corona; patented placer claim. Narrow, wedge-shaped fault sliver of Paleocene Silverado formation sedimentary clay, including red mottled, white, and gray clay and pisolitic clay with minor associated lignite, intercalated with Silverado sandstone and conglomerate. Wm. G. McVicar shipped clay to the California Clay Manufacturing Co., Los Angeles, about 1900. Later acquired by Earl M. McClintock who shipped some clay to Mission Clay Products Olive, during the early 1950's. Acquired by Sky Ranch Clay Co. in 1954. Early development was by short adits and open cuts, recent mining has been from open pits. Deposit apparently has very little areal extent beyond the pit limits. Production not determined, but appears to be small. Intermittently mined by Sky Ranch Clay Co. which see herein. (Aubury 06:223.)
22	Switzer	Elmo Switzer, 808 West 8th St., Corona (1957) owns about 50 acres, patented ranch land	NE¼ 5	4S	7W	SB	Adjoins Findley graphite placer on the east and Sky Ranch Clay Co. on the south, 3½ miles southwest of Corona. Buff Upper Cretaceous clay shales of the Ladd formation, undifferentiated, were explored by bulldozer cuts about 1945. A white sandy clay zone 2 to 5 ft. thick occurs along a shear zone which strikes N. 50° W., dips 40° NE. Small amounts of this white sandy clay "ganister" were mined from an open cut by the Sky Ranch Clay Co. about 1945 for use at Tillotson Refractories Co., Corona. Idle since except for occasional sampling.
23	Thomas clay deposit, east pit	Charles A. Thomas, P.O. Box 518, Corona, leased to Gladding, McBean & Company, 2091 Los Feliz Blvd., Los Angeles; sublet and operated by Joe Delco, Jr., 1233 Garretson, Corona (1957)	NW¼ 33	3S	7W	SB proj.	About 3½ miles southwest of Corona, west of Wardlow Wash. Red-burning clay shale of the Paleocene Silverado formation is mined and furnished to several manufacturers of common clay products. Production each year of a few thousand tons. (Herein.)
24	Thomas clay deposit, west pit	Charles A. Thomas, P.O. Box 518, Corona, leased to Gladding, McBean & Co., 2091 Los Feliz Blvd., Los Angeles (1957)	NW¼ 33	3S	7W	SB proj.	About 3½ miles southwest of Corona, west of Wardlow Wash. Paleocene clay shale of the Silverado formation is being developed as a constituent for common clay products. No production except for testing. Active development carried on in 1956. (Herein.)
25	Unnamed pit	Temescal Water Co., Corona (1957). Liston Brick Co., P.O. Box 4, Corona (operator, 1956)	NE¼ 16	4S	6W	SB proj.	About 4½ miles southeast of Corona on east side of Temescal Canyon. Liston Brick Co. intermittently mines small tonnage of soil developed on Triassic Bedford Canyon formation metasedimentary rocks for use in red brick. Material removed from small, shallow open pits; loaded on small dump trucks by combination bulldozer-loader.
26	Unnamed prospect	P. J. Oertel, E. I. Downs, A. J. Velthoen, W. B. Munn, W. J. Wood, c/o P. J. Oertel, Marilyn Dr., Corona (1957). Patented ranch land	SE¼ 33	3S	7W	SB proj.	West side Wardlow Wash, 3 miles west of Corona. White and pink, mottled, impure, sandy clay of Paleocene Silverado formation. Strike of beds N. 60° W., dip 45° to 60° NE; overlain by pebble arkose. Developed by caved pit or shaft 10 ft. deep in 1957. Apparently no production. Long idle.
27	Unnamed prospect	Mrs. Graciosa V. and Bernard W. de Pipkin, Harvard St., Los Angeles (1956); patented ranch land	NE¼ 4	4S	7W	SB proj.	Flat-topped ridge east of Wardlow Wash, 2½ miles southwest of Corona. Gray and white, brownish-buff, iron-red to limonite-yellow colored mottled clay bed 5-10 ft. thick, intercalated with white arkose and conglomerate of Paleocene Silverado formation. Developed by two shallow open cuts. Apparently no production. Long idle.

CLAY—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
28	Unnamed prospect	Joy G. and Walter T. Jameson, Corona (1957); S.R.C. Lands (1926)	SW¼ 3	4S	7W	SB proj.	Three miles southwest of Corona. Reddish-brown pisolitic clay bed strikes N. 50° W., dips 55° NE. Clay bed 3 ft. thick is exposed along a strike length of 30 ft.; overlain by clayey reddish sandstone, underlain by 2 ft. of white and gray fire clay which grades downward into red iron stained clayey sandstone and buff arkose. Developed by several small prospect pits. Apparently no production, long idle. (Dietrich 28; map facing p. 162.)

CLAY PRODUCTS MANUFACTURING PLANTS

1	Gladding, McBean and Co., Corona Plant	Gladding, McBean and Co., 2901 Los Feliz Blvd., Los Angeles 39	NW¼ NW¼ 16	4S	6W	SB	Plant location: 5 road miles southeast of Corona on State Highway 71. Manufactures vitrified clay pipe and conduit. See Bedford Canyon (Corona) clay deposit herein.
	Jordan Tile Manufacturing Co.	Mosaic Tile Co., Zanesville, Ohio	NE¼ 26 Corona	3S North	7W quad.	SB	Plant location: 909 Railroad St., Corona, manufactures quarry tile and vitreous tile. (Herein.)
29	Liston Brick Company	Lionel P. Liston, P.O. Box 4, Corona	SE cor. NW¼ 16	4S	6W	SB	Plant location: 5½ road miles southeast of Corona on State Highway 71, in lower Bedford Wash. Manufactures red brick from raw clay materials purchased from producers in the Corona South quadrangle. (Herein.)
	Pacific Clay Products, Corona Plant	---	---	---	---	---	See Tillotson Refractories Company.
	Tillotson Refractories Company	Pacific Clay Products, 1255 West Fourth St., Los Angeles (acquired Sept. 1, 1957); Tillotson Refractories Co., Clifford Tillotson, 1150 West 6th St., Corona (owner, 1945-Sept. 1, 1957)	SW¼ 26 Corona	3S North	7W quad.	SB proj.	Plant location: 1150 West 6th St., Corona, manufactures vitrified clay sewer pipe in several sizes. Supplies small amounts of ground fire clay and pipe layers clay. (Herein.)

COAL

30	Castillo's	Arthur E. Garratt, 3340 Eastern Ave., Los Angeles 32 (1957); patented land, former railroad section	NW¼ 29	4S	6W	SB	About 5½ miles southeast of Corona. Coal prospect on east bank of Bedford Canyon shown on U.S. Bureau Land Management survey map dated 1892. Red mottled clay, claystone and minor amounts of pisolitic clay and lignite of the Paleocene Silverado formation are exposed in a small, steep canyon. No development work noted in July 1956. Long idle.
	Hoag Ranch	---	---	---	---	---	See Jones.
	Hoffman's prospect	---	---	---	---	---	See Jones.
	Jones (Hoffman's prospect, Hoag Ranch)	---	---	---	---	---	See Jones under clay.
	McKnight	Pacific Clay Products, 1255 West Fourth St., Los Angeles (1957)	NE¼ 9 SW¼ 3 NW¼ 10	4S	7W	SB	In 1888 a bed of coal was observed to crop out in rocks that probably have since been removed in coal mining operations. The bed showed a strike of about N.70°W. and dipped 65° to 70° NE, but was very irregular in thickness and quality. At the surface it was an impure streak from 1 to 2 ft. thick; about 50 feet down it widened to 4 ft. of rather clean soft coal. Below this it pinched out to only 3 or 4 inches with an irregular dip. Production not determined, but probably small for local use. See McKnight under clay. (Goodyear 88:505.)
31	Unnamed prospect	Arthur Weirick, Chase & Skyline Dr., Corona (1956); patented ranch land	NW¼ 10	4S	7W	SB	North side of Tin Mine Canyon 3½ miles southwest of Corona. Early day local resident reports there was a caved adit and considerable dump area with lignite at the location in 1907 (personal communication, Mrs. Irene J. Ware, Corona, 1957), on old McKnight ranch, probably part of McKnight's coal prospect which see herein. No trace of adit or dump was found in 1957.

GOLD

No.	Name of claim or mine	Owner (name and address)	Location Sec.	T.	R.	B. & M.	Remarks and references
	Cliff No. 1						See Red Rock under dimension stone.
	Sam No. 1						See Red Rock under dimension stone.
32	Williams (Ophir ?)	Undetermined (1957)	SW¼ 4 NW¼ 9	5S 5S	7W 7W	SB SB	About one airline mile north of Silverado Post Office in Ladd Canyon, in the vicinity of the junction with the west fork of Ladd Canyon; Orange County. Long idle. (Tucker 25:59-60; herein.)

GYPSUM

No.	Name of claim or mine	Owner (name and address)	Sec.	T.	R.	B. & M.	Remarks and references
	Barth (Prizer)	Undetermined (1957); H. A. Prizer, address undetermined (1909); W. C. Barth, address undetermined, acquired in 1914.		4S	7W	SB	Location undetermined. Small production of gypsite for agricultural use reported in 1909, 1914, 1917. Previously published location—sec. 2 (Ver Planck, 1952, p. 124)—not confirmed; sec. 2 is wholly covered by older alluvium (Qalo). This location may have been for a grinding or storage area; the gypsum probably was obtained from the Eagle Canyon-Tin Mine Canyon gypsite belt. (Merrill 19:579, Ver Planck 52:125.)
33	Big Chief (Freeman-Nonhof, White gypsum group, Ware)	P. E. Coleman, 301 Fruit St., Santa Ana (1957). G. R. Freeman and E. R. E. Nonhof, Corona (1923); leased to Dr. Leon N. Katz, 9837 Foothill Blvd., San Fernando (1943); Howard S. and Irene J. Ware, 219 E. Olive St., Corona, (owners, 1947)	SE¼ 9 SW¼ 10	4S	7W	SB	South side of Tin Mine Canyon, 3½ miles southwest of Corona. Formerly part of White Gypsum group (see herein) with a small production of gypsite reported in 1923. Developed by several short adits 10 to 30 ft. long and shallow open cuts. Sampled and exposed by bulldozer cuts in 1943. Later abandoned. Relocated in 1954 by P. E. Coleman as Big Chief placer (20 acres), location amended 1956. Trenching and sampling in progress, December 1956.
34	Capitol Dome group	Floyd N. Champion, et al., 3316 E. Anaheim St., Long Beach 4 (1957)					See Main Street (Gypsum) Canyon deposit.
35	Eagle Canyon (Frazer)	T. A. and F. M. Fraser, 718 Howard St., Corona (1957); leased to Dr. Leon N. Katz, 9837 Foothill Blvd., San Fernando (1943-44)	Lots 1 & 2 SW¼ 13 N½NW¼ 24	4S	7W	SB	Both sides and west of Eagle Canyon, about 4 miles south of Corona. Small production of gypsite for agricultural use 1913-17, 1944. (Merrill 19:579; Tucker & Sampson 45:168; Ver Planck 52:58, 125, 132, herein.)
	El Cerrito Ranch	Undetermined (1957)					Small tonnage of gypsite reported to have been produced in period 1915-17 for private agricultural use; probably from Eagle Canyon-Tin Mine Canyon gypsite belt. (Merrill 19:579; Ver Planck 52:135.)
	Elki	George S. Jones, 3262 Santa Ana St., South Gate (1957)	SW¼ 10	4S	7W	SB	Three claims Elki 1-3, located in 1956. Developed by open trenches and adit 30 ft. long. See White Gypsum group.
	Frazer						See Eagle Canyon.
	Freeman-Nonhof						See White Gypsum group and Big Chief.
	Gypsum Canyon						See Main Street Canyon.
36	Hagador Canyon	W. R. and Virginia Adams, 301 Fruit St., Santa Ana; Orrin M. Pierce, 1607 N. Flower St., Apt. G, Santa Ana; A. F. Bullard and Wm. H. Redding, 1008 S. Pacific Ave., San Pedro (1957)	NW¼ 15 NE¼(?) 16	4S	7W	SB	Hagador Canyon, 4 miles southwest of Corona. Veinlets of satin spar and gypsite in hydrothermally altered volcanic rock (Santiago Peak volcanics). Idle except for annual assessment work which includes trenching and sampling. (Merrill 19:579; Symons 28:269; 35:279; Tucker & Sampson 45:168-169; Ver Planck 52:57-58, 126, 132, 142, 144; herein.)
	Jameson	Undetermined (1957); W. H. Jameson Co., Corona, (1915)	3 (?)	4S	7W	SB	W. H. Jameson Co. is reported to have produced a small amount of gypsite in 1915 for private use on orchards. Location of deposit, given by Ver Planck (1952, p. 126) as sec. 3, is doubtful because the only gypsum found there today is a very minor amount associated with clay shales of the Paleocene Silverado formation. Probably the gypsum was mined from the Eagle Canyon-Tin Mine Canyon gypsite belt. (Merrill 19:579; Ver Planck 52:126, 138.)
37	Main Street (Gypsum) Canyon	Josephine Middlesworth, 847 W. 9th St., Corona (1 claim 1957); Floyd N. Champion, et al., 3316 E. Anaheim St., Long Beach 4, (5 claims 1957); Middlesworth property leased to Dr. Leon N. Katz, 9837 Foothill Blvd., San Fernando (1944) and to Victor Mishelle, West Los Angeles (1945)	NE¼ 15 SE¼ 14 W½ 14	4S 4S	7W 7W	SB SB	Main Street Canyon, 4 miles south of Corona. Intermittent production of gypsite 1900-1935. Idle except for annual assessment work. (Aubury 06:286; Merrill 19:579; Tucker & Sampson 45:168, Ver Planck 52:57-58, 126, 136, 140; herein.)

GYPSUM—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
	Omei	Mrs. B. I. Markwell, 1001 N. Lowell St., Santa Ana (1957)	S½ 9	4S	7W	SB	See White Gypsum group.
	Prizer						See Barth.
	Red Bull						See Hagador Canyon.
	Tecumseh group	Orrin M. Pierce, 1607 N. Flower St., Apt. G, Santa Ana (1957)	SW¼ 10 SE¼ 9 NW¼ 15 NE¼ 16	4S	7W	SB	Parts of former White Gypsum and Hagador Canyon deposits (see herein). Five claims, Tecumseh, Minot, Why Not, Alpha, Omega. Idle.
	Ware						See White Gypsum group and Big Chief.
38	White Gypsum group (Freeman-Nonhof, Big Chief, Ware)	P. E. Coleman, 301 Fruit St., Santa Ana (1957); G. R. Freeman and E. R. E. Nonhof, Corona, (1923); W. E. Hill and E. R. E. Nonhof, 1116 Ramona St., Corona (1935); leased to Dr. Leon N. Katz, 9837 Foothill Blvd., San Fernando (1943); Howard S. and Irene J. Ware, 219 E. Olive St., Corona, (owners, 1947)	SE¼ 9 SW¼ 10 NE¼ 16	4S	7W	SB	South side of Tin Mine Canyon, 3½ miles southwest of Corona. Formerly a group of 8 unpatented claims (White Gypsum 1-8). Veinlets of satin spar and gypsite in hydrothermally altered volcanic rock (Santiago Peak volcanics). Developed by several small cuts, shallow pits, and short adits. Small production of gypsite reported in 1923; most of the material was used locally as a soil conditioner, small amounts may have been shipped for agricultural use. Acquired by H. S. Ware about 1940; area of present Big Chief claim (see herein) sampled and exposed by bulldozer cuts 1943; bulk sampling of White Gypsum group (then known as Ware Gypsum) 1947. Later abandoned and partly relocated in 1954-56 as Big Chief, Omei, Tecumseh, and Elki (see herein). (Ver Planck 52:127, 142, 146.)

LEAD-SILVER-ZINC

39	Corona lead-zinc mine	Robert A. Mattey, Jr., 11359 Biona Dr., Los Angeles 66 (1953)	SE¼ 14	4S	7W	SB	Manning Canyon 4 miles south of Corona. Mineralized fracture zone in Bedford Canyon formation. No record of production. Idle. (Tucker & Sampson 45:147-148; Goodwin 57:601-602; herein.)
	Ophir						See Williams under gold.
	Williams						See under gold.
40	Unnamed prospect	Undetermined (1957)	SE¼ 33	4S	7W	SB	About 2 airline miles north of Silverado Post Office on east side of West Fork of Ladd Canyon. Short adit, now caved; driven east-west across contact of Santiago Peak volcanic rocks and Bedford Canyon formation slate. Apparently an early day prospect. May have been part of the Williams (Ophir ?) mine, which see under gold.
41	Unnamed prospect	Undetermined (1957)	SE cor. NE¼ 11 SW cor. NW¼ 12	5S	7W	SB	About 3 road miles northeast of Silverado Post Office, Orange County. One adit north of Maple Springs truck trail driven N. 60° E., 100 ± ft. long; one short adit driven south, and one shallow pit south of truck trail. Adits driven in altered zones in hornblende andesite porphyry and rhyolite tuff (?), intrusive and volcanic rocks related to Santiago Peak volcanics. Prospecting probably dates from about 1880. Production, if any, not determined; idle many years.

LIMESTONE

	Kroonen						See Ladd Canyon.
42	Ladd Canyon (Kroonen)	Great West Minerals and Materials Development Co., 8541 Calmada Ave., Whittier (1958); Leo Kroonen, Jr., Corona (1931)	SE¼ 34 NE¼ 3	4S 5S	7W 7W	SB SB proj.	2½ airline miles northeast of Silverado Post Office, along west side of East Fork of Ladd Canyon, Orange County. Several small limestone pendants within graywacke and slate of Triassic Bedford Canyon formation. Long idle. (Fairbanks 93:115-116; Smith 98:779; Tucker 25:68; Logan 47:261; herein.)
	Nonhof	Undetermined (1957); E. R. E. Nonhof, 1116 Ramona Ave., Corona (1924)	16 (?)	4S	7W	SB	Hagador Canyon; one claim located in 1915 on which the owner reported a bold outcrop of lime, 1,500 ft. long, about 70 ft. wide, and 50 ft. thick; developed by a short adit. The writer was unable to locate such an outcrop in 1953, although several small exposures of pyrite and limonite-bearing medium-grained crystalline limestone were found, and limy metashales occur in the Triassic Bedford Canyon formation in the area. Several short adits have been

LIMESTONE—Continued

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
	Nonhof Continued						driven. These may have been the source of "limestone" for a small kiln in upper Hagador Canyon. Ruins of a kiln are said to have been found in 1907, but were not identifiable in 1953.
43	Unnamed prospect	Undetermined (1957)	NW¼ SW¼ 32	4S	6W	SB	7¾ miles southeast of Corona, just east of Bedford Motorway. Discontinuous pendant, 20 to 30 ft. wide and about 1,000 ft. long, of dark gray fine-grained limestone. Weathers light gray. Apparently in part breccia. Strikes N. 65° E., dips 75° NW. Occurs within graywacke and slate of Triassic Bedford Canyon formation. Reserves are apparently small. Undeveloped prospect. Analysis by Abbot A. Hanks, Inc., June 1956, of one random type sample collected by the writer was as follows: SiO_2 Fe_2O_3 Al_2O_3 CaO MgO P_2O_5 9.18% 0.80% 9.18% 43.74% 0.83% 0.03%

MINERAL PAINT (OCHER)

	Lord	Undetermined (1957); George W. Lord, Corona (operator, 1905)		4S	7W	SB	Exact location undetermined; probably was in the area of NW¼ sec. 14, NE¼ sec. 15, 3½ miles SW of Corona. Aubury (1906, p. 339) reported a bed of fine-grained, light colored, yellow ocher 8 ft. wide in a deposit of fire clay. Numerous prospect pits and open cuts and several caved adits expose Paleocene Silverado formation clays in this area, none active in 1956. This deposit may be part of several claims now held by Josephine Middlesworth, 847 W. 9th St., Corona or on patented ranch land owned by W. H. Redding, 1008 S. Pacific Ave., San Pedro. See Middlesworth clay herein. Long idle. (Aubury 06:339; Merrill 19:579; Symons 30:156.)
	National Paint and Color Company	Undetermined (1957); National Paint and Color Co., Corona (operator, 1905)		4S	7W	SB	Exact location undetermined; probably was in NW¼ sec. 14, 3½ miles SW of Corona. This firm produced about 20 colors of natural pigments (ocher, red oxide, vermillion red, grays, etc.) in Corona in 1905. Reported to have held extensive clay deposits near Corona; one tract of 20 acres contained a 5-foot bed of ochre stated to be of a very choice quality. Long idle. (Aubury 06:339; Symons 30:156.)
	Paint mine	Undetermined (1957); George W. Lord, Corona (owner, before 1905); Corona Pressed Brick and Terra Cotta Co., Corona (owner, 1905)		4S	7W	SB	Exact location undetermined; probably was in the area of NW¼ sec. 14, NE¼ sec. 15, 3½ miles SW of Corona. Property developed by G. W. Lord. Reported to be about 500 yds. NW of the Lord deposit, described herein. Long idle. (Aubury 06:339; Symons 30:156.)

ROCK PRODUCTS
Broken and Crushed Stone

	Blue Diamond Materials Co.						See Temescal rock quarry under roofing granules.
44	Jameson quarry	Mary C. Jameson, 316 E. Olive St., Corona (1957); J. B. Stringfellow, P.O. Box 6, Riverside (operator, 1940, 1950)	SW¼ 29	3S	6W	SB proj.	One mile west of Home Gardens, north of State Highway 18. Pinkish-gray micropegmatite granite was quarried intermittently from 1940-50. Idle since. (Herein.)
	Matich Brothers quarry						See Temescal Canyon rock quarry.
	Phillips						See Sidebotham.
45	Sidebotham (Phillips) quarry	William N. Guth, Chicago, Illinois (1957); A.T. & S.F. R.R. Co. (operator, 1935-39)	W½ NW¼; NW¼ SW¼ 5	4S	6W	SB proj.	About 2½ miles southeast of Corona on the south margin of Temescal Wash. Granodioriate was quarried intermittently from 1935 to 1939 and used for railroad track ballast and riprap. Idle since about 1939. (Herein.)
46	Temescal Canyon rock quarry	Frank Spires, Corona and Wesley Collins, Costa Mesa (1957); leased to Temescal Rock Products Co., P.O. Box 364, Corona (operator, May-July 1957); Matich Brothers Contractors, Colton (operator, Sept. 1957)	SW¼ 33 NW¼ 4	3S 4S	6W 6W	SB proj. SB proj.	East side of Temescal Wash, 1¼ airline miles south of Home Gardens. Quarry opened in May 1957, in granodioriate for use as riprap on Santa Ana River levee west of Riverside. (Herein.)

ROCK PRODUCTS—Continued

Broken and Crushed Stone

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
	Temescal Rock Company	----------------	----------	------	------	------	See Temescal rock quarry under roofing granules.
	Temescal Rock Products Co.	----------------	----------	------	------	------	See Temescal Canyon rock quarry.

Decomposed Granite

No.	Name of claim or mine	Owner (name and address)	Sec.	T.	R.	B. & M.	Remarks and references
47	Unnamed pit	Alfred H. and Sue M. Beazley, 601 Fern Drive, Fullerton (1957); patented ranch land	SW¼ NE¼ 4	5S	6W	SB	Ridge midway between Bixby and Anderson Canyons about 8 miles southeast of Corona. Brownish-gray, soft, much weathered biotite quartz diorite (phase of San Marcos gabbro); largely altered to clay minerals, breaks into very fine-grained material. Small amount scraped from ridge by bulldozer during 1956, probably used locally by ranchers to surface unpaved roads. Idle since Dec. 1956.
48	Unnamed pit	Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul, Minn. and P.O. Box 276, Corona (1957)	NE¼ NW¼ 9	4S	6W	SB proj.	Northwest of El Cerrito Village and about 3½ miles southeast of Corona. Light brownish-gray, soft, weathered, quartz monzonite (Home Gardens quartz monzonite porphyry) with minor hard, light-gray blocks. Developed by two small, nearly connected quarries totaling about 100 ft. in length with face from 10 to 25 ft. high; mined by power shovel without blasting. Small intermittent production, probably used locally to surface unpaved roads. Idle.

Dimension Stone

No.	Name of claim or mine	Owner (name and address)	Sec.	T.	R.	B. & M.	Remarks and references
49	Red rock prospect	Cecil J. and Helen L. Clark, 1908 S. Parton, Santa Ana, (1952)	NE¼ 28	4S	7W	SB	Two placer claims: Red Rock & Mari-Etta were located for building stone in 1952, ¼ mile west of Pleasants Peak along the Main Divide Truck Trail, Orange County. This is probably the same area earlier located as Cliff No. 1 and Sam No. 1 lode claims and held by Cliff Overacker and Sam Clapp during the 1930's. These were gold-silver prospects. The building stone claims include a small outcrop of serpentine which is bordered on one side by a massive ledge of reddish-brown silica-carbonate rock, but most of the area is occupied by weathered diorite and andesite. This material probably will not find special favor in the building industry, but some might be useful in ornamental stonework. Development consists of several shallow pits and cuts and one short adit. The property was inactive in July 1956, and little recent work has been done.
50	Unnamed prospect	Cecil J. Clark, 1908 So. Parton, Santa Ana (1952?)	NE¼ 33	4S	7W	SB	Placer claim (20 acres) for "building stone" located on the ridge between Ladd Canyon and the West Fork of Ladd Canyon about 2½ miles north of Silverado Post Office, Orange County. Area underlain by platy, fine-grained white to buff quartzite of the Bedford Canyon formation; thin bedded altered tuffs (?) and porphyritic andesite of the Santiago Peak volcanics. Reached by one mile of foot trail from Pleasants Peak. Developed by several shallow pits. In June 1956 no recent activity was evident.

Roofing Granules

No.	Name of claim or mine	Owner (name and address)	Sec.	T.	R.	B. & M.	Remarks and references
51	Temescal rock quarry	Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul, Minn., and P.O. Box 276, Corona (1957); Temescal Rock Co. (1914); Blue Diamond Materials Co., Los Angeles (1927)	4, 5, 9	4S	6W	SB proj.	Quarry and processing plant for fine granules used in processed roofing on east side of Temescal Canyon, 4 miles southeast of Corona. Processing plant for coloring coarse granules (used in built-up roofing) north of Corona City park on East 3rd St. Quartz latite porphyry quarried for road metal and riprap, 1888-1927; used for roofing granules since 1948. (Goodyear 88:506; Merrill 19:586-587; Tucker 21:331-332; 24:45; Allen 23:887-890; Bradley 23:95; Tucker & Sampson 29:508, 524; 45:166-167; Ingram 49: 457; Utley 49:5pp; Megaphone 51.6-7; Jahns 54:21; herein.)

ROCK PRODUCTS—Continued
Sand and Gravel

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
52	Corona Rock Co.	Riverside County Flood Control District (1957); Corona Rock Co., (Bill Flynn, operator 1937-1939?)	W½ 32	3S	6W	SB proj.	Two miles southeast of Corona, along the east side of the city dump. Several small, shallow pits 10-15 ft. deep expose dirty, silty sand with sparse gravel. A small sand and gravel plant was erected about 1937, but was dismantled after several years. Production undetermined, but small. Long idle.
	Kuster & Waterbury						See Transit Mixed Concrete Co.
53	Transit Mixed Concrete Co., Corona plant	Transit Mixed Concrete Co., 3464 E. Foothill Blvd., Pasadena (1957)	29, 30	3S	6W	SB proj.	One mile east of Corona at northwest end of Temescal Wash, north of State Highway 18. Only the south edge of the mined out pit area is within the Corona South quad; plant and active pit are ½ mile northwest in Corona North quad. Plant operated for many years by Kuster and Waterbury before 1942; since then worked by present operator. Large production (see sand and gravel herein).
54	Unnamed prospect	Mrs. R. Boyd and W. Heinlein, 3264 Floresto Ave., Los Angeles (1957); 50 acres leased to Temescal Rock Products Co., P.O. Box 364, Corona (1957); patented ranch land	SE¼ 28	4S	6W	SB	Lower Brown Canyon, 7 miles southeast of Corona. Deposit of stream gravels, said to be 80% rock with average depth of 40 ft. Undeveloped 1957.

Specialty Sands (Glass Sand)

No.	Name of claim or mine	Owner (name and address)	Sec.	T.	R.	B. & M.	Remarks and references
55	Corona silica sand deposit (Owens-Illinois Glass Co., Corona sand plant No. 96; P. J. Weisel Industrial Sand Co.)	Louis A. Weisel, et al., La Habra (1957); leased to Owens Illinois Glass Co., 350 Sansome St., San Francisco (operator, 1957)	SE¼ 16 NE¼ 21	4S	6W	SB	Athwart State Highway 71 on west side of Temescal Wash 5½ miles southeast of Corona. Quartz-rich Paleocene sands are processed to furnish large tonnage of clean, high-silica sand used to make glass. Operated by P. J. Weisel Industrial Sand Co. from about 1920 to 1945; by Owens-Illinois Glass Co. since then. New plant built in 1947 has been in continuous operation since January 1948. (Tucker & Sampson 29:504; 45:163-164; herein.)
56	Coronita Ranch sand deposit	Donald C. McMillan, 8704 Colima Rd., Whittier, and Joel D. Middleton, 9531 Heather Road, Beverly Hills (1957)	SW¼ 16 E½ SE¼ 17	4S	6W	SB	Lower Bedford Wash 4½ miles southeast of Corona, adjoins northwest part of Corona sand deposit. Exploratory drilling in April 1957 penetrated quartz-rich Paleocene sand. Deposit has not been developed. (Brown 57:8 pp.; herein.)
	Findley feldspar placer						See under clay.
	Hoag Ranch						See Jones sand deposit.
57	Jones (Hoag Ranch) sand deposit	Riverside Cement Company, Division of the American Cement Corporation, P.O. Box 832, Riverside (1958)	SW¼ 17	4S	6W	SB	Ridge between Bedford and Joseph Canyons, 4 miles southeast of Corona. Pliocene unconsolidated sand. Long idle except for extensive drilling and sampling done in September, 1958. (Tucker & Sampson 29:505; 45:163; Sampson and Tucker 31:443; herein.)
	Nonhof						See under foundry sand.
	Owens-Illinois Glass Co., Corona sand plant No. 96						See Corona silica sand deposit.
58	Temescal Canyon silica sand deposit	Arthur E. Garratt, 3340 Eastern Ave., Los Angeles 32 (1957); patented land former railroad section; L. M. Freeman, Los Angeles (1931)	NE¼ 29	4S	6W	SB	Five miles southeast of Corona, southeast of Bedford Motorway. Coarse, weakly indurated white arkose of the Vaqueros and Sespe formations, undifferentiated; and Silverado formation sandstone. Production undetermined but apparently small, if any, and before 1930. (Sampson and Tucker 31:444, herein.)
	P. J. Weisel Industrial Sand Company						See Corona sand deposit.

ROCK PRODUCTS—Continued
Specialty Sands (Foundry Sand)

No.	Name of claim or mine	Owner (name and address)	Location				Remarks and references
			Sec.	T.	R.	B. & M.	
59	Jackson & Havens	William H. Redding, et al., 1008 S. Pacific Ave., San Pedro (1957); George W. Lord, Corona (1924); leased to Jackson and Havens, Riverside (operator, 1924)	SW¼ (?) 11	4S	7W	SB	Three miles southwest of Corona midway between Main St. and Hagador Canyons, along the margin of the Santa Ana Mts. A bed of white "molding" sand about 30 ft. thick composed of coarse, white, sub-angular arkose (Paleocene Silverado formation) overlain by about 2 ft. of gravel and soil overburden (Quaternary terrace) reported under development in 1924 by Jackson and Havens, Riverside; this deposit, discovered in 1917, was worked intermittently prior to 1924, but apparently not since. The deposit was worked by open cuts, the material being loaded into small mine cars and transported to loading bins. During 1922 sand was shipped to Union Tool Co., Los Angeles. Production undetermined, but apparently small. By 1956 all equipment had been removed.
60	Nonhof	Arthur Weirick, Chase & Skyline Dr., Corona (1956); E. R. E. Nonhof, 1116 Ramona Ave., Corona (1924)	NW¼ 10	4S	7W	SB	Three miles southwest of Corona, west side of lower Hagador Canyon. Bedded deposit of sand, 50 ft. thick, reported in 1924 to occur in unconsolidated sands, gravels and clays (of Paleocene Silverado formation). Sand deposit covered about 2 acres with a 5 ft. overburden of gravel and soil (Quaternary terrace). This deposit, discovered in 1900, is reported to have been productive before 1907 (personal communication, Mrs. Irene J. Ware, Corona) and may be one of the glass sand deposits noted by Aubury (1906, p. 375) as under development by the Corona Pressed Brick Co., about 1905. Development in 1924 consisted of open cuts and one adit 50 ft. long; by 1956 the workings were not identifiable and may have been destroyed by work at the adjacent McKnight clay mine. Production undetermined, but apparently small. Long idle. (Aubury 06:375.)

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STATE OF CALIFORNIA
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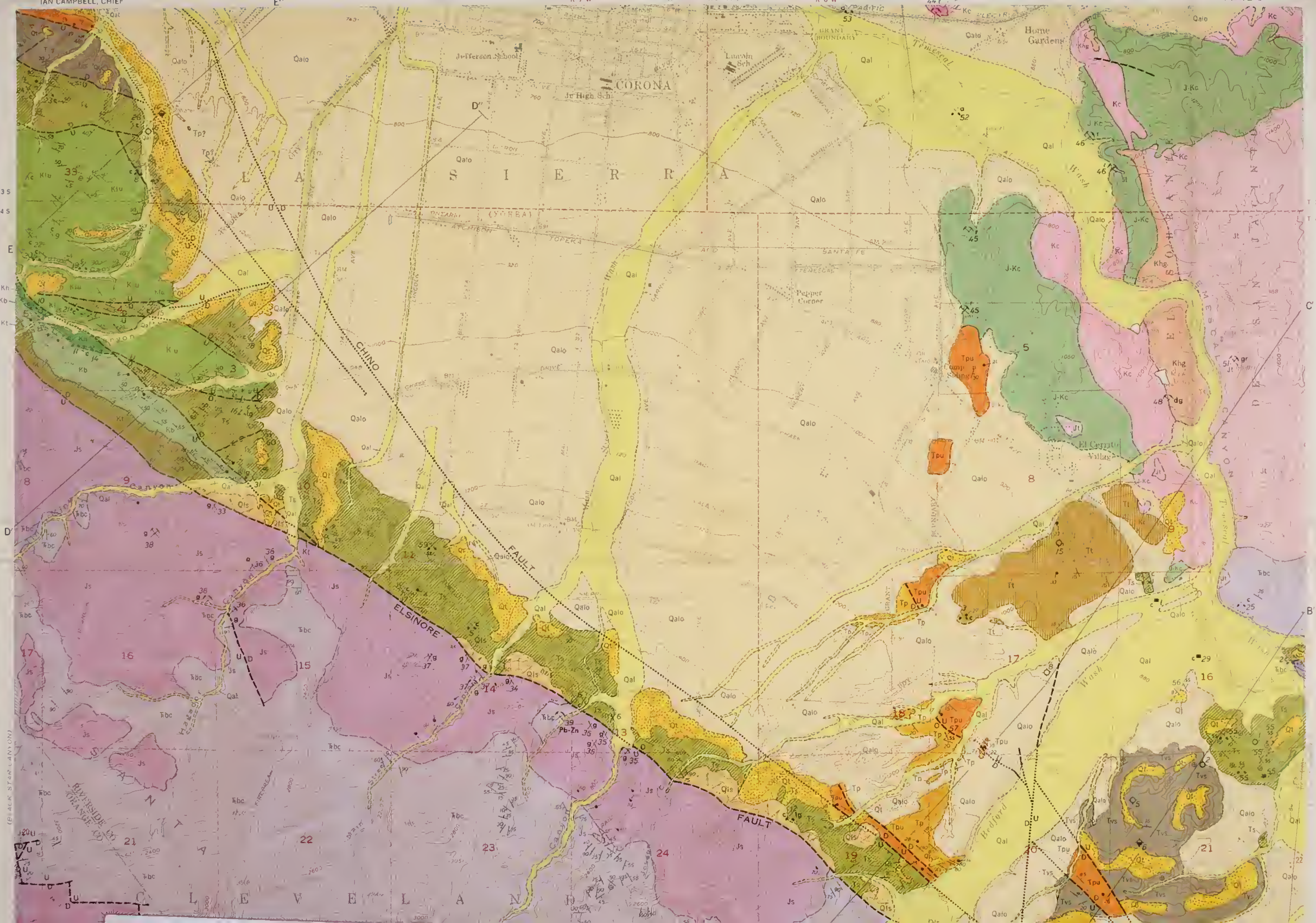
BULLETIN 178
PLATE 1



EXPLANATION

SURFICIAL DEPOSITS

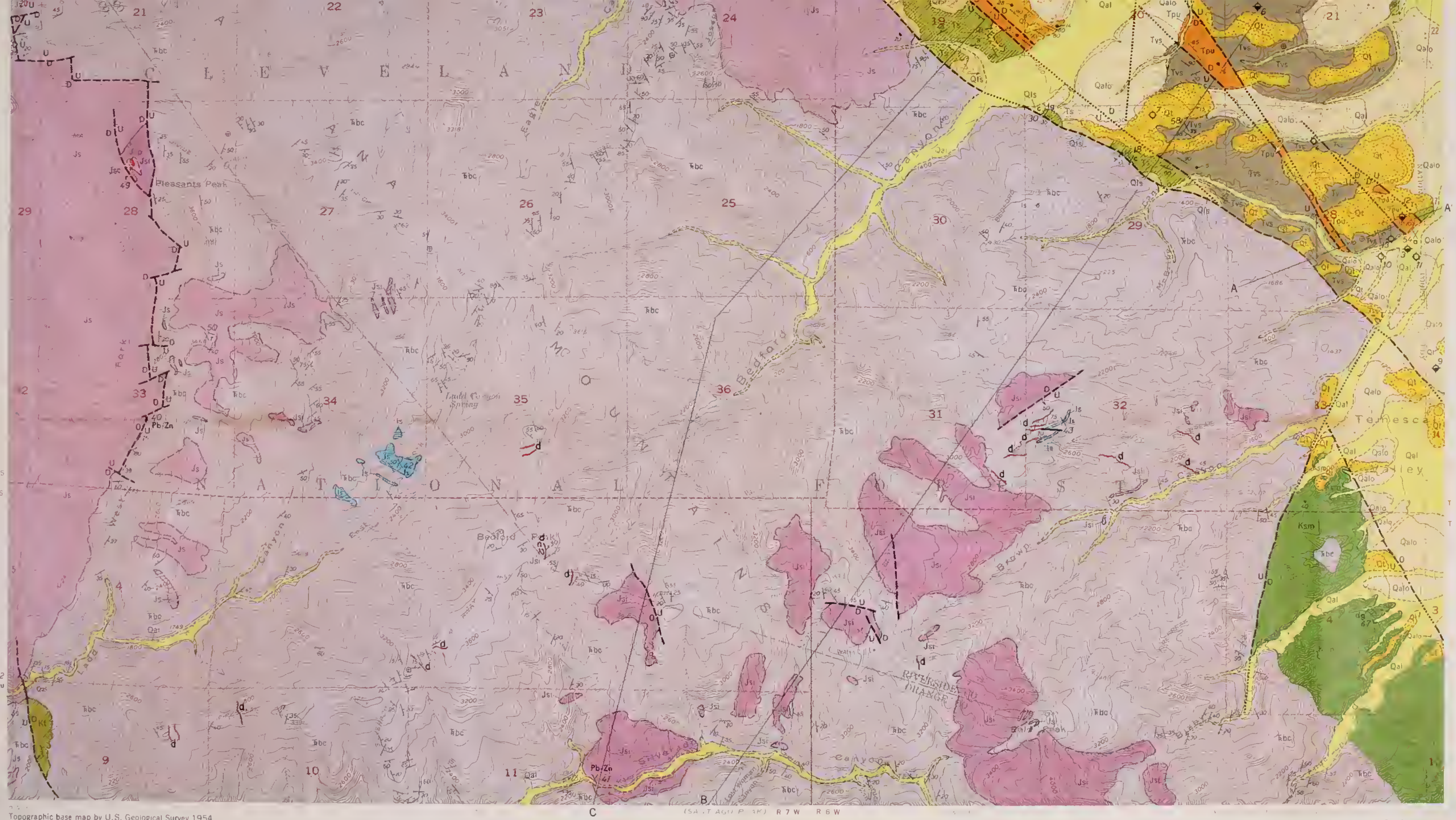
Period	Epoch	Symbol	Unit	Description
QUATERNARY	Recent	Qls	Landslide	
		Qal	Alluvium	*Gravel, sand, silt*
	Pleistocene (?)	Qalo	Older alluvium	*Sand, gravel, and rubble; buff and gray in color*
		Qt	Terrace deposits	*Rubble, gravel, and sand; reddish-brown to buff in color*

SEDIMENTARY ROCKS

Period	Epoch	Symbol	Unit	Description
TERTIARY	Pliocene	Tp	Pliocene undifferentiated	*Thick-bedded sandstone and conglomerate with lesser amounts of sandy silts and shales, marine*
	Miocene, Upper	Tpu	Puente formation, undifferentiated	*Sandy siltstone and shale, minor amounts of sandstone, conglomerate and diatomite, marine; contains abundant Mohnian and a few Luisian foraminifera*
	Miocene, Middle	Tt	Topanga formation	*Buff sandstone, conglomerate, and sandy siltstone, marine*
	Upper Eocene to lower Miocene	Tvs	Vaqueros (lower Miocene) and Sespe (upper Eocene? to lower Miocene?) formations, undifferentiated	*White, buff, red, and green sandstone, conglomerate, sandy clay and siltstone, in part nonmarine, upper part contains early Miocene or lower middle Miocene marine fossils*
	Paleocene	Ts	Silverado formation	*Upper part marine greenish-gray sandstone and conglomerate, buff siltstone and shale, lower part nonmarine or brackish water coarse-grained micaceous sandstone, conglomerate, clay, and minor lignite. Residual clay at base*
CRETACEOUS	Upper Cretaceous	Klu	Ladd formation, undifferentiated	*Greenish gray sandstone and conglomerate, buff siltstone and shale, marine*
	Upper Cretaceous, Ladd formation	Kh	Holz shale member	*Gray to black silty shale and siltstone with limy concretions, marine*
	Upper Cretaceous, Ladd formation	Kb	Baker Canyon conglomerate member	*Buff sandstone and buff and gray to greenish gray conglomerate, marine*
	Upper Cretaceous	Kt	Trabuco formation	*Red, buff and grayish-green massive conglomerate, minor sandstone, probably nonmarine*

IGNEOUS & METAMORPHIC ROCKS

Period	Symbol	Unit	Description
ACEOUS (?)	Kmp	Micropegmatite granite	*Pink, fine-grained granular rock*
	Khg	Home Gardens quartz monzonite porphyry	*Light gray biotite quartz monzonite*



Topographic base map by U.S. Geological Survey 1954

Topography from aerial photographs by multiplex methods
and by plane-table surveys 1933
Aerial photographs taken 1952. Field check 1954

Polyconic projection 1927 North American datum
10,000-foot grid based on California coordinate system, zone 6

Dashed land lines indicate approximate locations

GEOLOGIC AND ECONOMIC MAP OF THE CORONA SOUTH QUADRANGLE, CALIFORNIA

By Cliffton H. Gray, Jr.

1960

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1954

SCALE 1 24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
DASHED LINES REPRESENT HALF INTERVAL CONTOURS
DATUM IS MEAN SEA LEVEL

CRETACEOUS (?)

Micropegmatite granite
Pink, fine-grained granular rock

Khg
Home Gardens quartz monzonite porphyry
Light gray biotite quartz monzonite

Kc
Cajalco quartz monzonite
Pinkish to tan massive granitic rock

Ksm
San Marcos gabbro
Dark medium-grained rock, quartz diorite to gabbro

J-Kc
Corona hornblende granodiorite porphyry
Dark gray porphyritic rock, abundant mafic minerals

JURASSIC (?)

Jt
Temescal Wash quartz latite porphyry
Blue-black to gray quartz latite to dacite porphyritic rock

Js
Santiago Peak volcanics
Andesitic and dacitic flows and breccias, slightly metamarphosed

Jsi Jsp Jsc
Intrusive rocks related to Santiago Peak volcanics
Andesitic and dioritic bodies, slightly metamorphosed; Jsp, *serpentine;* Jsc, *silica carbonate rock*

TRIASSIC

T̄bc ls
Bedford Canyon formation
Dark gray to brown argillite, slate and graywacke, with thin beds of quartzite and limestone; ls, *area mostly of limestone*

SYMBOLS

Contact, dashed where approximately located

Indefinite contact

Inferred boundaries

Fault, showing dip (dashed where imperfectly exposed, dotted where concealed)
U, *upthrown side;* D, *downthrown side*

Strike and dip of beds	Overturned beds
Strike of vertical beds	Horizontal beds
Strike and dip of joints	Strike of vertical joints

Dike (dacites & andesites; 5 to 30 ft. thick; related to Jsi).

Fossil locality
(See table in text)

Mine or quarry	Prospect
Sand, gravel or clay pit	Mineral products processing or manufacturing plant

Au = gold Pb-Zn lead-zinc a = aggregate c = clay
dg decomposed granite g gypsum gr = roofing granules
lg = lignite ls = limestone r = rock ss = specialty sands

Water well	Oil well, dry hole with show of oil or gas	Oil well, dry hole

(See tabulated list in text)

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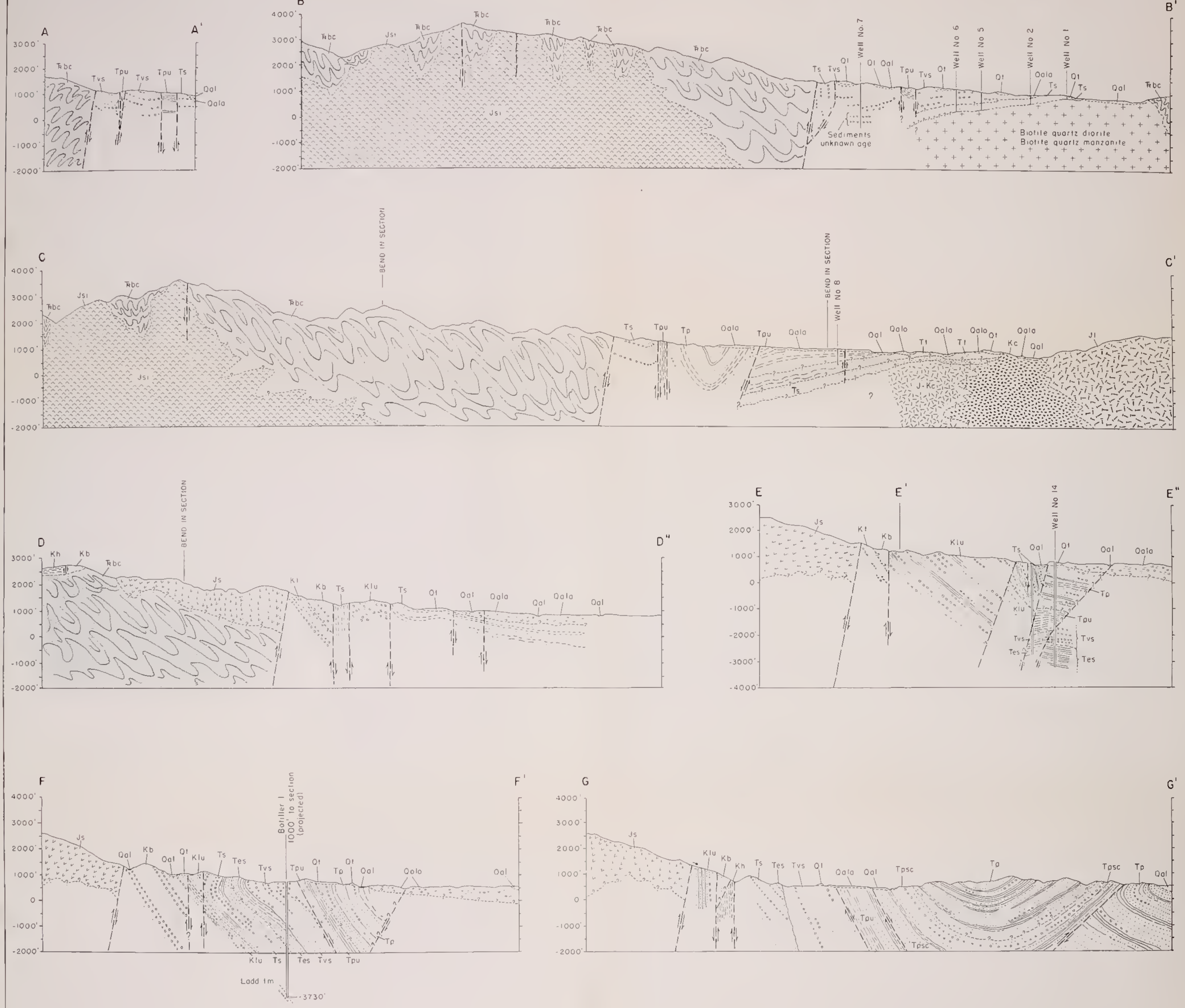

MAP SYMBOLS

Contact
dashed where approximately located

Inferred boundaries

Landslide

Fault
showing relative movement

EXPLANATION

Qal, alluvium, Qala, older alluvium; Qt, terrace deposits; Tp, Pliocene, undifferentiated, Tpu, Puente formation, undifferentiated; Tpsc, Sycamore Canyon member (Puente formation); Tt, Topanga formation; Tvs, Vaqueros and Sespe formations, undifferentiated, Tes, Santiago formation; Ts, Silverado formation; Klu, Ladd formation, undifferentiated, Kh, Holz shale member (Ladd formation), Kb, Baker Canyon conglomerate member (Ladd formation), Kt, Trabuco formation; Kc, Cajalco quartz monzonite; J-Kc, Corona hornblende grano-diorite porphyry, Jt, Temescal Wash quartz latite porphyry; Js, Santiago Peak volcanics; Jsi, intrusive rocks related to Santiago Peak volcanics; Ʀbc, Bedford Canyon formation

For full description see explanation on Plate 1, for well records see Figure 45

SCALE IN MILES

1 .5 0

by Cliffton H Gray, Jr

GEOLOGIC SECTIONS OF CORONA SOUTH QUADRANGLE AND SANTA ANA NARROWS AREA,

RIVERSIDE, ORANGE, AND SAN BERNARDINO COUNTIES, CALIFORNIA

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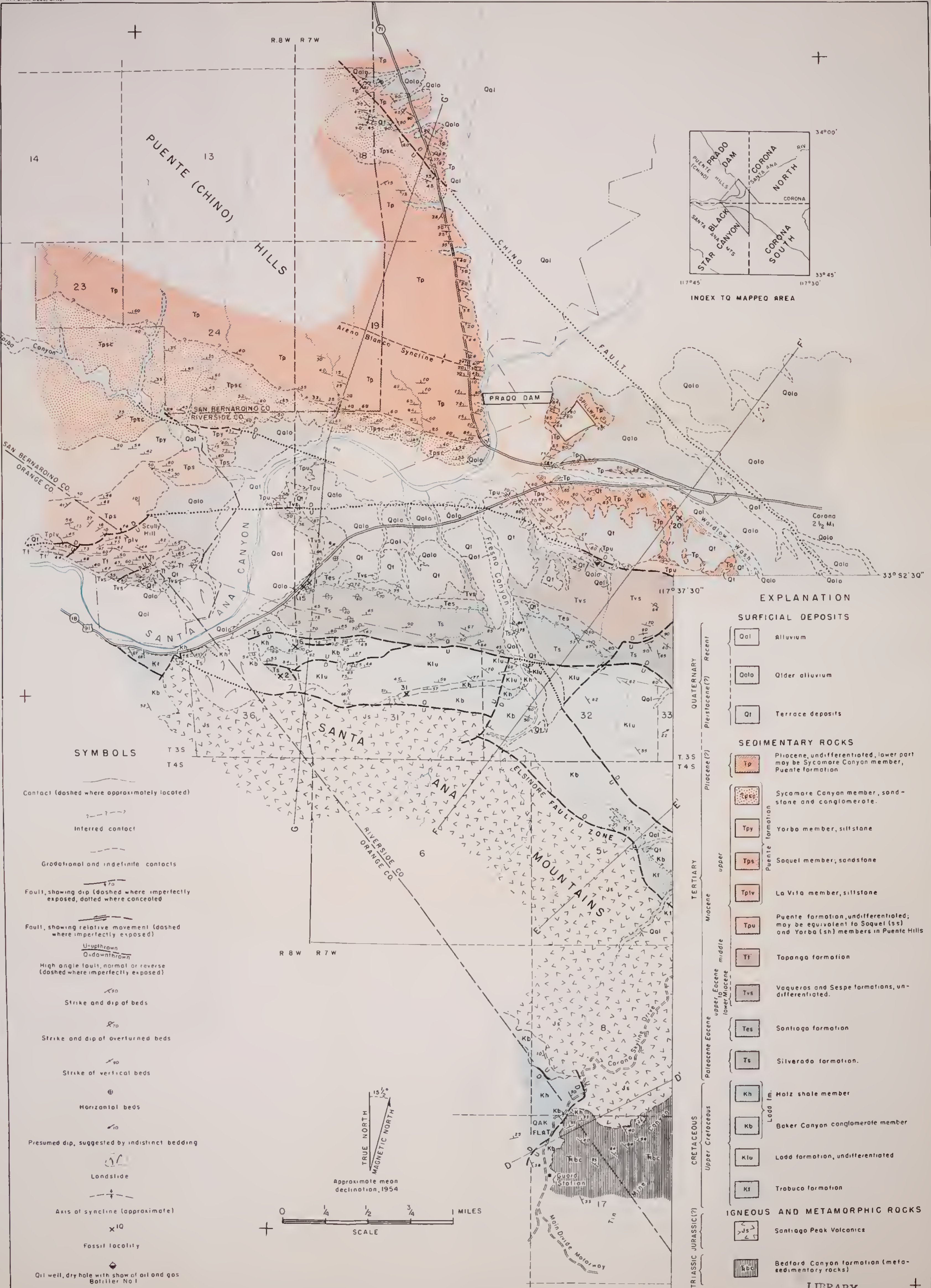
PUENTE (CHINO) HILLS
SANTA ANA MOUNTAINS
SANTA ANA CANYON
CHINO FAULT
ELSINORE FAULT ZONE
Arena Blanco Syncline
PRADO DAM
SPILLWAY
Fresno Canyon
Wardlow Wash
Scully Hill
OAK FLAT
Guard Station
Main Divide Motorway
Corona Skyline Drive
Corona 2½ Mi
SAN BERNARDINO CO.
RIVERSIDE CO.
ORANGE CO.
R.8W R.7W
T.3S T.4S
33°52'30"
117°37'30"
INDEX TO MAPPED AREA
PRADO DAM
CORONA NORTH
CORONA SOUTH
BLACK STAR CANYON
PUENTE (CHINO) HILLS
SANTA ANA MTS
CORONA
34°00'
33°45'
117°45'
117°30'
EXPLANATION
SURFICIAL DEPOSITS
QUATERNARY
Recent
Qal Alluvium
Qolo Older alluvium
Pleistocene(?)
Qt Terrace deposits
SEDIMENTARY ROCKS
TERTIARY
Pliocene (?)
Tp Pliocene, undifferentiated, lower part may be Sycomore Canyon member, Puente formation
Puente formation
Tpsc Sycamore Canyon member, sandstone and conglomerate.
Tpy Yorba member, siltstone
Tps Soquel member, sandstone
Tplv La Vida member, siltstone
Miocene upper
Tpu Puente formation, undifferentiated; may be equivalent to Soquel (ss) and Yorba (sh) members in Puente Hills
middle
Tt Topanga formation
upper Eocene to lower Miocene
Tvs Vaqueros and Sespe formations, undifferentiated.
Paleocene Eocene
Tes Santiago formation
Ts Silverado formation.
CRETACEOUS
Upper Cretaceous
Ladd fm.
Kh Holz shale member
Kb Baker Canyon conglomerate member
Klu Ladd formation, undifferentiated
Kt Trabuco formation
IGNEOUS AND METAMORPHIC ROCKS
JURASSIC(?)
Js Santiago Peak Volcanics
TRIASSIC
Tbc Bedford Canyon formation (metasedimentary rocks)
SYMBOLS
Contact (dashed where approximately located)
Inferred contact
Gradational and indefinite contacts
Fault, showing dip (dashed where imperfectly exposed, dotted where concealed)
Fault, showing relative movement (dashed where imperfectly exposed)
U=upthrown
D=downthrown
High angle fault, normal or reverse (dashed where imperfectly exposed)
Strike and dip of beds
Strike and dip of overturned beds
Strike of vertical beds
Horizontal beds
Presumed dip, suggested by indistinct bedding
Landslide
Axis of syncline (approximate)
Fossil locality
Oil well, dry hole with show of oil and gas Bolriler No 1
TRUE NORTH
MAGNETIC NORTH
13½°
Approximate mean declination, 1954
0 ¼ ½ ¾ 1 MILES
SCALE

Base map from U.S. Geol Survey Corona North, Prado Dam, and Black Star Canyon Quadrangles

Geology by C. H. Gray, Jr., 1951-57. Geology in Black Star Canyon Quadrangle in part after Schoellhamer et al., 1954

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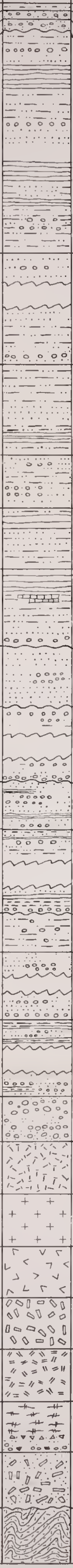

AGE			FORMATION	MEMBER	MAP SYMBOL	MAXIMUM THICKNESS OUTCROP	LITHOLOGY	DESCRIPTION
CENOZOIC	QUAT	RECENT	Alluvium		Qal	100'		Gravel, sand, silt.
		RECENT (?) & PLEISTOCENE	Older Alluvium		Qalo	100'		Reddish-brown to buff gray dirty sand and gravel, a few boulders.
			Terrace Deposits		Qt	150'		Reddish- brown to buff and gray dirty sand and gravel, angular, some boulders. Unconformity
	TERTIARY	PLIOCENE (?)	Pliocene (undifferentiated)		Tp	3000'		South of Chino Fault: Heavily-bedded white sandstone and conglomerate, with lesser amounts of buff to gray sandy silts and shale. North of Chino Fault: Mostly buff to gray sandy silt and shale. Minor conglomerate and sandstone lenses. Marine.
		UPPER AND MIDDLE (?) MIOCENE	Puente	Sycamore Canyon	Tpsc	2700'		Coarse sandstone and conglomerate, with interbedded siltstone. Marine.
				Yorba Shale	Tpy	1200'		Buff to gray, massive to fissile siltstone, interbedded fine sandstone. Marine.
				Soquel Sandstone	Tps	700'		Sandstone and conglomerate, minor amount of interbedded buff and gray siltstone. Marine.
				La Vida Shale	Tplv	800'		Buff to gray siltstone, minor interbedded sandstone. Marine.
			Puente (undifferentiated)		Tpu	1000' ?		Buff to pinkish-gray siltstone and shale, considerable diatomite, numerous hard limy beds up to 1 ft. thick with many Miocene forams, minor amounts of buff to tawny sandstone and cobble conglomerate. Marine. Unconformity
		MIDDLE MIOCENE	Topanga		Tt	800'		Buff to tawny sandstone, siltstone and shale, minor cobble conglomerate. Marine. Unconformity
		LOWER MIOCENE TO UPPER EOCENE (?)	Vaqueros (lower Miocene) and Sespe (upper Eocene to lower Miocene) formations, undifferentiated		Tvs	2300'		White to buff, red, and green sandstone and grit with conglomerate up to 70% composed of red and purple volcanic clasts. Minor amount of greenish-gray siltstone. Interfingering marine and non-marine. Unconformity
		EOCENE	Santiago		Tes	600'		Interbedded sandstone, siltstone and conglomerate with numerous red volcanic clasts. Sparse Eocene fauna, Turritella cf. T. buwaldana. Marine.
		PALEOCENE	Silverado		Ts	2000'(?)		Interbedded sandstone, siltstone, grit and conglomerate Buff to red basal clay horizon with minor amount of pisolitic clay and lignite. Red mottled residual clay at base. Good Paleocene fauna, Turritella pachecoensis Marine and non-marine, probably interfingering. Unconformity
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	Ladd	Holz Shale	Kh	500'		Gray to black silt, large limy concretions. Locally contains silty clay. Marine.
				Baker Canyon	Kb	1400'		Buff to tawny heavily-bedded sandstone and conglomerate Good fauna: Trigonarca californica, Glycymeris racificus. Marine.
			Ladd (undifferentiated)		Klu	3500'		Buff siltstone and shale; buff to white sandstone and sandy conglomerate. Fragments of Upper Cretaceous ammonites from several localities. Marine.
		CRETACEOUS	Trabuco		Kt	600'		Red, buff and grayish-green boulder conglomerate, many red granitic clasts. Evidently grades laterally into Baker Canyon. Non-marine (?) Unconformity
		CRETACEOUS ?	Home Gardens quartz monzonite porphyry		Khg			Light gray porphyritic to porphyro-aphanitic biotite quartz monzonite. Includes pink micro pegmatite granite west of Home Gardens.
			Cajalco quartz monzonite		Kc			Pinkish to tan massive granitic rock.
			San Marcos gabbro		Ksm			Dark. medium grained granitic rock. Extremely variable; from hornblende quartz diorite to hypersthene biotite gabbro, with diabasic or ophitic texture.
	JURASSIC	JURASSIC ?	Corona hornblende granodiorite porphyry		J - Kc			Dark porphyry rock with slightly variable texture and composition of granodiorite.
			Temescal Wash quartz latite porphyry		Jt			Blue-black to gray quartz latite to dacite porphyritic rock.
			Santiago Peak volcanics		Js			Slightly metamorphosed andesitic and dacite flows and breccias, volcanic conglomerate at base. Non-marine (?)
			Intrusive rocks related to Santiago Peak volcanics		Jsi			Small hypabyssal intrusive masses. Mostly hornblende andesite and diorite. Slightly metamorphosed. Unconformity
	TRIASSIC		Bedford Canyon		T̄R bc	?		Argillites and slate; considerable quartzite; minor amount of limestone. Marine.

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BULLETIN 178
PLATE 1

EXPLANATION

SURFICIAL DEPOSITS

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